KNOWLEDGE
AN ILLUSTRATED MAGAZINE OF SCIENCE, LITERATURE & ART.
Founded in 1881 by RICHARD A. PROCTOR.

LONDON: JULY 1, 1898.

CONTENTS.

	PAGE
The Karkinokosm, or World of Crustacea.—IV. By the Rev. THOMAS R. R. STEBBING, M.A., F.R.S., F.L.S. (*Illustrated*)	145
A Classic Legacy of Agriculture.—II. By JOHN MILLS. (*Illustrated*)	148
"The Mimic Fires of Ocean." By G. CLARKE NUTTALL, B.SC.	150
The Petroleum Industry.—II. By GEORGE T. HOLLOWAY, ASSOC. R.C.S. (LOND.), F.I.C. (*Illustrated*)	151
On the Eclipse Theory of Variable Stars. By Lieut.-Colonel E. E. MARKWICK, F.R.A.S. (*Illustrated*)	153
The Recent Eclipse.—The Lick Photographs of the Corona. By E. WALTER MAUNDER, F.R.A.S. (*Plate*)...	155
Notices of Books	156
SHORT NOTICES	157
BOOKS RECEIVED	157
Obituary	158
Letters:—W. H. S. MONCK; J. E. GORE	159
Science Notes. (*Illustrated*)	159
Self-Irrigation in Plants. By the Rev. ALEX. S. WILSON, M.A., B.SC. (*Illustrated*)	160
British Ornithological Notes. Conducted by HARRY F. WITHERBY, F.Z.S., M.B.O.U.	162
Botanical Studies.—IV. Mnium. By A. VAUGHAN JENNINGS, F.L.S., F.G.S. (*Illustrated*)	163
Notes on Comets and Meteors. By W. F. DENNING, F.R.A.S.	166
The Face of the Sky for July. By A. FOWLER, F.R.A.S. ...	167
Chess Column. By C. D. LOCOCK, B.A.	167

THE KARKINOKOSM, OR WORLD OF CRUSTACEA.—IV.

By the Rev. THOMAS R. R. STEBBING, M.A., F.R.S., F.L.S.

SEEING that the mammalian tail is allowed to contract or expand the number of its joints at discretion, it looks like a kind of obstinacy in natural arithmetic that has assigned seven vertebræ alike to the neck of the hippopotamus and the neck of the giraffe. Attention has already been drawn to a similar case of numerical persistence in the Karkinokosm. The whole of the great and diversified sub-class of the Malacostraca is bound together by the circumstance that the body segments never exceed twenty-one, and only fall short of that number when motives of personal convenience have induced a broad Cancrid, for example, to consolidate, or a threadlike Caprellid to relinquish, some of its somites. But the other great sub-class, the Entomostraca, prefers always to have a number of body segments greater or smaller than twenty-one. Between these two sub-classes some authors give an independent position to the little group of the Nebaliidæ.

Nebalia bipes has a wide distribution in the northern hemisphere. You may find it at Spitzbergen and in the Mediterranean. You may find it also under stones on the south coast of Devon, always exquisitely neat, however untidy the surroundings may be. In this half-inch of animal organism there can be counted twenty pairs of appendages, exactly the full number allotted to the Malacostraca, and implying a corresponding number of segments; but at the tail end of this creature there are two extra segments and a pair of caudal branches. Moreover, in *Nebalia* the eight pairs of limbs which follow the maxillæ are all of a peculiar pattern. The leglike character of the main stem is overshadowed by the great leaflike expansion of the subsidiary branches, which have a respiratory function: they act as branchiæ, or gills.

Though in Crustacea the gills are commonly enough connected with the feet, yet the order Branchiopoda has a special claim to take its name from this connection, because the branchial character of the feet, instead of being, as elsewhere, subordinate or modestly withdrawn from view, is here monstrously developed and prodigiously obtrusive.

The order Branchiopoda is so extensive a division of the Entomostraca that it has to be again divided into four sub-orders, with names that may not sound to all ears alluringly mellifluous, but which are moderately handy and in their measure significant. The four names are Phyllocárida, Phyllópoda, Cladócera, Branchiúra. These names, being interpreted, are Leafy Shrimps, Leafy Legs, Branching Antennæ, Gill Tails. Unfortunately the interpretation needs an interpreter, just as it is not enough for us to know that Hiawatha is the Teacher, and that his wife's name, Minehaha, means Laughing Water, or that Mudjekeewis is the West Wind, and that the Kingdom of Ponémak is the Land of the Hereafter. The poet needs five or six thousand lines to unfold the story of these names, and to bring the hero to the haven where he would be.

The Phyllocarida are represented by the border tribe of the Nebaliidæ. Till the voyage of the *Challenger* that little group contained but one genus. Now it has three, and it is a curious thing that in one of the two new forms the breathing legs are exceedingly long, while in the other they are exceedingly short, the old northern genus standing intermediate between them.

At no great distance from the Phyllocarida may be set the Phyllopoda, with a name that differs little from theirs either in sound or sense. It refers to the same feature in their construction—the leaflike limbs. The Phyllopods have been divided into three groups, closely connected, but, in one respect, singularly unlike. One set have a dorsal shield, leaving a long caudal part exposed; another set are enclosed in a pair of valves in such a way that they might well be mistaken for little molluscs; while the third set are really quite too informal, almost indecorously negligent of the conventionalities observed by the respectable class of Crustacea. These have no dorsal shield, no covering valves, no encrusting carapace; but each swims about unencumbered, a vagrant "neat and slim, without a rag to cover him."

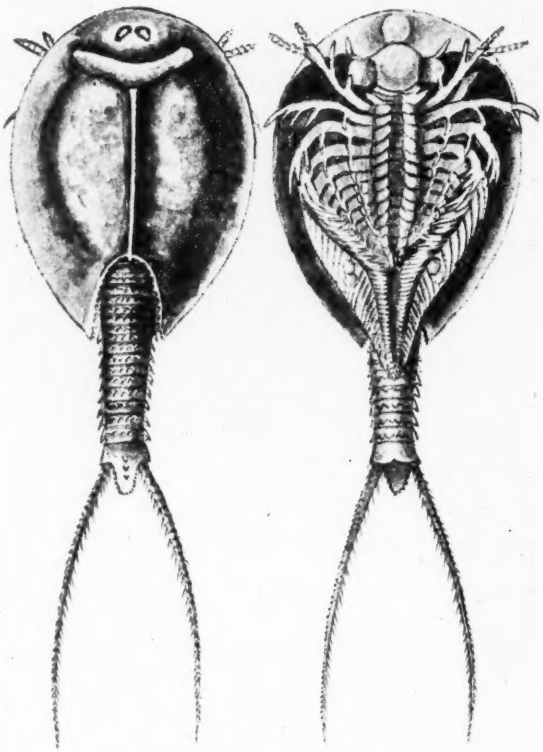
Of the last-mentioned group two forms were at one time well known in England, though of late years no one seems able to come across them. One of these, *Artemia salina*, the brine shrimp, occurred at Lymington, in Hampshire, myriads of these graceful little creatures curvetting and gambolling about in the strong brine of the salterns. They are not marine animals. None of the known Phyllopods exist in the sea. Not too many tears need be shed over our lost Lymington species, for it is known to inhabit in countless numbers shallow brackish-water ponds along the shores of Europe, and a very similar form abounds in the Great Salt Lake at Utah, in the United States of America. Our

other missing species is *Chirocephalus diaphanus*, the fairy shrimp. The name of the creature is deservedly prepossessing and rightly suggestive of its real beauty. Of this no picture conveys any adequate idea, because the great antennæ, or "hands on the head," to which the generic name refers, distract attention and look clumsy in a drawing; while the pellucid limpidity of the whole organism, its iridescent colouring, and the graceful vivacity of its motions belong to nature rather than art. One point in the history of this fairy is apt to excite a smile of incredulity, for it is said to be found in places quite out of harmony with the birth of an Oberon or a Titania—"in stagnant water, very often in the ditches and deep cart-ruts on the edges of woods and plantations." These woodland cart-ruts, as everyone knows, though soft and brimming with water at times, become at other times perfectly dry and of a stony hardness. It may seem, therefore, like one of Baron Munchausen's miracles to people these transient troughs with crustaceans an inch in length. They cannot fall from the sky. Spontaneous generation has never been accused of producing shrimps. The fact is that inland Entomostraca accommodate themselves, like the Rose of Jericho, to the exigencies of recurrent drought and varying seasons. Though they are inhabitants of water, their eggs can retain vitality unimpaired for long periods after complete desiccation of the mud in which they have been deposited. For observing the development and habits of numerous species belonging to the remotest lands, it is no longer necessary for the student to extend his survey by toilsome travel from China to Peru. He can engage a correspondent to send him by post a small piece of Australia or Egypt, a sample of Siberia or Ceylon. It is a pleasing experience to find a handful of earth, dug out of a pond at the other side of the globe, teeming with foreign species responsive to the gift of a cup of cold water poured upon the thirsty soil. In these experiments it is expedient in Great Britain to wake up a tropical brood, not amidst our frosts and fogs and chilling east winds, but when warm nights and summer sun, in which such broods delight, will favour their quick developing, until it can be said that—

Nebalia bipes (O. Fabricius).

> "Cupid, empire sure,
> Flutter'd and laugh'd, and ofttimes through the throng
> Made a delighted way."

These Phyllopods go through strange metamorphoses, for whereas in the full-grown condition they come to have from ten to more than sixty pairs of legs, they almost always begin life in what is called the *nauplius* stage, with no true legs whatever, having to be content with two pairs of antennæ and a pair of "mandibular legs" that are not permanent. With this limited apparatus they manage to jerk about in their watery world with tolerable activity. Instead of a pair of compound eyes the young ones are provided only with a central ocellus, the nauplian eye—sufficient, no doubt, for their childish wants. Like crustaceans in general, Phyllopods pass from stage to stage of development and of growth by shedding the skin. Their exuviæ are easy to collect and examine when the pond containing them is a bowl on a table. With the eye-



Dorsal View. Ventral View.

Lepidurus arcticus (Pallas).*

* "Fauna Norvegiæ," Bd. I., Tab. XI. By G. O. Sars. 1896.

cases and antennæ, the oral parts and the respiratory limbs, the bright spines and feathered hairs—all the delicate structure, glassily transparent, is exposed to view, like the wreathèd pearls, the unclasped jewels, and the rich attire which Madeline had put off on that famed Eve of St. Agnes, when, enamoured and entranced, "Porphyro gazed upon her empty dress."

The Phyllopod's story, however, is not exclusively romantic. The cultivation of many species in a small bowl is convenient for the observer, but it also gives the stronger forms great and not always unwelcome facility for preying on the weaker. A couple of the *Estheria gihoni*, figured in the first chapter, caused me much surprise one summer for two reasons. First, the pair attained an unwonted size, which implied that the conditions were healthy; but, secondly, contrary to custom, all other animals, even those of the same species, though grown under the same conditions, speedily disappeared. At last the pair that had waxen fat were put to death, just to see what would happen, and straightway a brood of young *Estheriæ* grew up and prospered. It seems scarcely uncharitable to infer that the long-dominant pair had thriven on cannibalism. In the kindred genus, *Limnadia*, there is another strange circumstance which interferes with romance. Of this genus only two species are as yet known—one European and one American—and in neither of them has any specimen of the male sex been observed. The propagation, according to Prof. G. O. Sars (an unsurpassed authority), is exclusively parthenogenetic. "Males," he says, "in spite of the most careful investigation, have not yet been found, and probably do not exist." It is not a little wonderful that these Amazons should occur in a group which commonly has both sexes abundantly represented. But perhaps the effacement of the inferior sex will prove even here not to be quite so absolute as for the moment it seems, although the Russian and Hungarian naturalists, Krynicki and Chyzer, who claim to have observed the males, may have been deceived as to the species they examined.

The division of the Phyllopods with a carapace or dorsal shield contains the largest of all the species, *Apus australiensis* Spencer and Hall, nearly three inches long, and *Lepidurus macrurus*, exceeding an inch and a half in length. It is in this division also that the legs reach the surprising number of a hundred and twenty-six. This being the case, it will appear an odd thing that the primary genus, which is scarcely or not at all to be distinguished from *Lepidurus*, should have been called *Apus*—that is to say, "the legless." The explanation is this. The ingenious Dr. Johannes Leonhard Frisch, who in 1732 published the first description and figures of what he called "the fin-footed lake worm with the shield," did not overlook the little packet of almost innumerable leaflets under the trunk, but decided that they were more like fins than feet. He therefore obligingly left it open for those who thought them legs to call this "insect" or "water worm" a *polypus*—that is, "many legs," while for him it was preferentially an *apus*, or "no legs."

In the Apodidæ it may be noted that the males are very rare; and abundant as the females are in some parts of the world, the student in England may not always find specimens at his command. He can always solace himself by having recourse to the Cladocera. These are distinguished by the conspicuously branched second pair of antennæ, which are their swimming organs. They content themselves with a comparatively parsimonious number of legs—from four to six pairs—and have the whole body except the head encased in valves, which, for the benefit of the naturalist, are often conveniently transparent. In all countries may be found some puddle, pool, or pond, some swamp, or tarn, or lake; and therefore in all countries the zoologist may recognize a link with home by finding *Daphnia pulex* or one of its near relations. In numbers numberless may members of this prolific tribe be obtained by dipping a net into almost any horsepond. Their movements can be studied by transferring a few to a tumbler of water: their organization by isolating one in a watch-glass under the microscope. No Röntgen rays are needed. The living works of the machine are plain for all folk to see. It is worth taking a little trouble to observe the winking of that ever-trembling eye, the motions and adornment of the branchial feet, the little pulsating heart, the strokes of the spiniferous tail, the curious sinuosity of the intestine. One may chance to see the eggs pouring from the ovary and taking shape in the maternal pouch. Often within that pouch may be seen numerous eggs or young ones forward in development. *Daphnia* is like *Apus*, the prevalent method of reproduction being, as Dr. G. S. Brady expounds the matter, "not sexual at all, but parthenogenetic, the female producing and detaching in rapid succession broods of young, which are the result of the development, not of fertilized eggs, but of mere buds or "pseudova." The fertilized eggs, the winter eggs, the eggs which keep and pass the winter

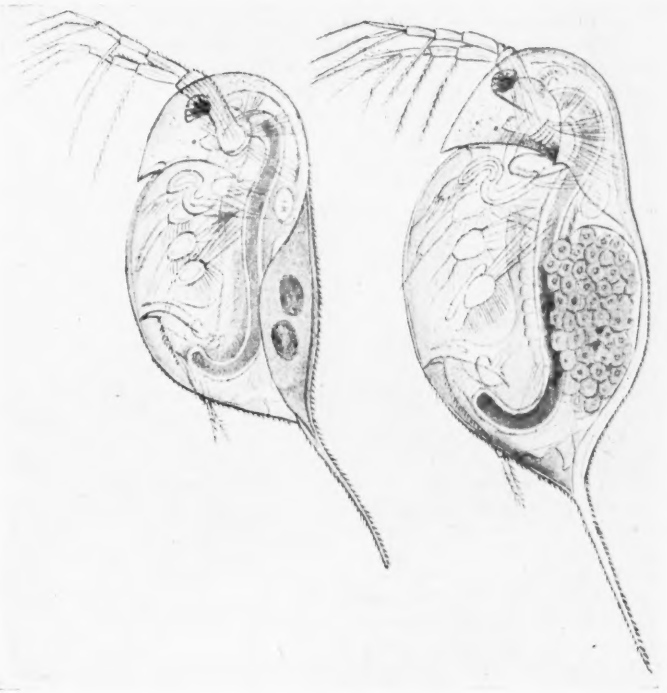


Fig. on left, *Daphnia carinata*, var. *intermedia* Sars, female with ephippium.
Fig. on right, typical form of *Daphnia carinata* King, ovigerous female.*

* "On Fresh-water Entomostraca from the Neighbourhood of Sydney, partly raised from Dried Mud." By G. O. Sars. Pl. I. 1896.

independent of maternal care, are laid in the so-called "ephippium"—a case developed in the mother for this special purpose, and subsequently detached. An old writer has been scoffed at for speaking of *Daphnia pulex* as a "wonderful insect." It is not in modern classification an insect. Of forms now known which belong to the same social set it is by no means the most eccentric. It is not rare, but, on the contrary, multitudinously common. None the less, it is to my mind easy to sympathize with Bradley when he called it wonderful.

A CLASSIC LEGACY OF AGRICULTURE.—II.

By JOHN MILLS.

THERE is no more beneficial creation of wealth than that which arises from the complete development of the resources of the soil and the correct manipulation of its products. Better education in agriculture would contribute largely to an intelligent appreciation of the problems which arise in farming as a business, and increase the efficiency of the mental machinery destined to direct operations in the field. Farmers of the future, whose minds are thus counterpoised and adjusted so as to retain their equilibrium under all conditions—favourable and unfavourable—will play an important part in the struggle for supremacy between civilized countries; and, so equipped, complete confidence may be placed in the ability of the tillers of the soil in our own country to maintain a secure place in the markets with rivals, distant and near, who make it their chief occupation to supply our population with food. In the attainment of such knowledge a great multitude of facts present themselves for consideration, each of which requires due thought to discern its bearing on the whole and to assign it a place in agriculture so as to render the science of maximum usefulness. Thus, the quantity and quality of the crops, the character of the soil and of the climate, differences in the habits of plants, general economy of the farm, and so on, give rise to a number of questions which form a sort of algebraic equation involving many unknown quantities, and to solve which requires not only a vast amount of exact observation, but also profound skill in the marshalling of facts and manipulation of data. The experiments at Rothamsted, conducted by Sir John Lawes and Sir Henry Gilbert, are of this complicated description, some of the results being merely tentative.

The object to be attained in the cultivation of root crops is to encourage, by artificial means, a quite abnormal development of a particular part of the plant. If, for example, the turnip plant were grown for its natural seed-product oil, a heavier soil would be more suitable than when the object is to develop the swollen root. When grown in ordinary soil without manure, either for a few years in succession or even in rotation, root crops soon revert to the uncultivated condition; they depend for luxuriant growth on an abundance of nitrogenous as well as mineral constituents within the soil, and they are therefore generally highly manured. In the accompanying table, the results obtained with Norfolk white turnips are shown,

NORFOLK WHITE TURNIPS, WITHOUT MANURE, AND WITH FARMYARD MANURE.

Year.	Roots per Acre.		Leaves per Acre.	
	Without Manure.	With Farmyard Manure.	Without Manure.	With Farmyard Manure.
	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.
1843	4 4	9 10	not weighed	not weighed
1844	2 4	10 15		
1845	0 14	17 1	0 14	7 8

and it will be noted that when grown without manure the crop dwindles down almost to zero, whilst with farmyard manure there is a marked increase year by year. The form of the unmanured root resembles that of a carrot more than a turnip, and its composition is totally different from the cultivated root. There is, indeed, much more nitrogen taken up by the latter, but the percentage of that element—apparently lower than in the unmanured plant—is masked by the accumulation of a large amount of other matters which render the plant an important food crop. The average proportion of leaf to root under different conditions as to manuring clearly indicates the susceptibility of these plants to artificial influences: to one thousand of root with mineral manure alone, the yield of leaf being three hundred and twenty-nine; with mineral and ammonium salts, four hundred and thirty-four; and with mineral and ammonium salts and rape cake, six hundred.

Potatoes have been grown on the estate for twenty-two years in succession, different sorts being selected on the supposition that in growing the crop year after year change was desirable, especially with a view to the avoidance or lessening of disease. It is now an established fact that season has much to do with the development of the potato disease, and these experiments show that there was on the average much more disease in the wetter seasons. When the unsuitable weather comes, those tubers suffer the most which have the richest juice—that is, the least fixity of composition. The first material change in the development of the disease is, apparently, the destruction of starch and the formation of sugar; there is also a considerable loss of organic and chiefly *non*-nitrogenous substance, due in part to the decomposition of the produced sugar, but probably in some measure to the evolution of carbonic acid, as a coincident of the growth of the fungus at the expense of ready-formed organic substance, this being a characteristic of the growth of such non-chlorophyllous plants. Regarding the cultivation of the plant under varying conditions, it is somewhat interesting to observe that the produce of starch per acre was about one thousand one hundred pounds without manure, nearly two thousand pounds with purely mineral manure, and with nitrogenous and mineral manures together about three thousand four hundred pounds. In other words, the increased produce of starch by the use of the mineral and nitrogenous manures together was more than one ton per acre. That is to say, there was a great increase in the production of the *non*-nitrogenous constituent, *starch*, by the use of nitrogen in manure—a striking result, indeed, and one more hint that nature will have her own way, paradoxical though it may seem to us. In truth, it is for the production of the non-nitrogenous substances—starch, sugar, and cellulose—that our direct nitrogenous manures are chiefly used!

The fixation of free nitrogen directly from the atmosphere is a subject which has engaged the attention of many inquirers, notably Sir John Lawes and Sir Henry Gilbert at Rothamsted; and a theme of much controversy among scientific men for many years past has been—"How is the fixation of nitrogen to be explained?" Diversity of opinion still obtains on this question, and, unfortunately, there is yet much to learn before a satisfactory answer can be given; but though the explanation is wanting there can be no doubt that the fact of the fixation of free nitrogen in the growth of leguminosæ—clover, vetches, peas, beans, sainfoin, lucerne, and so on—under the influence of suitable microbe infection of the soil, and of the resulting nodule formation on the roots, may be considered as fully established. What, then, is the basis of this conclusion? Recent experiments at Rothamsted show that, by adding to a sterilized sandy

soil growing leguminous plants a small quantity of the watery extract of a soil containing the appropriate organisms, a marked development of the so-called leguminous nodules on the roots is induced; and that there is, coincidently, increased growth and gain of nitrogen. For example, in growing peas, there was limited growth in pot 1 (*see* figure) with sand without soil extract, and also an entire absence of nodule formation on the roots. The increased growth in pots 2 and 3, with soil extract, was coincident with a very great development of nodules. In pot 4, with garden soil, itself supplying abundance of combined nitrogen and doubtless micro-organisms as well, there was also a considerable development of nodules, but distinctly less than in either pot 2 or pot 3 with sand and soil extract only. Further, without soil extract and without nodules there was no gain of nitrogen, but with soil extract and with nodule formation there was much gain of nitrogen. Experimental results, in fact, clearly prove that there is immense gain of nitrogen under some

Peas grown in Experiments on the Fixation of Free Nitrogen.

conditions. It has also been conclusively shown that due infection of the soil and of the plant is an essential to success. The available evidence at the same time points to the conclusion that the soil may be duly infected for the growth of some descriptions of plants, but not for some other descriptions. Moreover, land which is, so to speak, quite exhausted so far as the growth of one leguminous crop is concerned, may still grow very luxuriant crops of another description of the same order, but of different habits of growth, and especially of unlike character and range of roots.

Not only the facts ascertained in the Rothamsted experiments and in other investigations, but also the history of agriculture throughout the world, so far as it is known, clearly show that a fertile soil is one which has accumulated within it the residue of long periods of previous vegetation, and that it becomes infertile as this residue is removed. That this exhaustion proceeds slowly may be gathered from the fact that wheat has been grown at Rothamsted for more than fifty years in succession on the same land, and, setting aside fluctuations due to season, the produce has only been reduced by an average of about one-sixth bushel per acre per annum, due to exhaustion. Without any manure whatever, the average annual produce for over fifty years was thirteen and a half bushels—a yield exceeding the average of the United States under ordinary cultivation, including their rich prairie lands, and about the average of the whole world. The accompanying table

Averages.	14 Tons Farmyard Manure every Year.	Without Manure every Year.	Mixed Mineral Manure alone.	Ammonium Salts alone.
	Bushels.	Bushels.	Bushels.	Bushels.
8 years, 1852-59 ...	34⅜	16⅛	19	32⅜
8 years, 1860-67 ...	35¼	13½	15¼	31¼
8 years, 1868-75 ...	35⅜	12¼	14	28½
8 years, 1876-83 ...	28⅜	10½	12⅜	27¾
8 years, 1884-91 ...	39¼	12⅝	13¾	32½
20 years, 1852-71 ...	35½	14½	17	31⅝
20 years, 1872-91 ...	33½	11½	12⅞	29½
40 years, 1852-91 ...	34⅞	13	15	30¼
50 years, 1844-93 ...	33½	13½	—	—

shows that with farmyard manure the average annual produce over the fifty years of continuous growth was thirty-three and a half bushels—a result not far short of three times the average produce of the United States, and more than two and a half times the average of the whole of the wheat lands of the world. Artificially manured plots show that mineral manures alone gave very little increase of produce; that nitrogenous manures alone gave considerably more than mineral manures alone; but that mixtures of the two gave very much more than either separately. An inspection of the following table of results, as indicating the amounts of produce in the best and in the worst seasons of the forty years, will show how easy it is to form wrong conclusions as to the effects of different manures if experiments are conducted for one season only, or in only a few seasons, and if the characters of the seasons are not studied and due allowance made accordingly in drawing

Wheat Year after Year on the Same Land.—Produce of the Best Season, 1863; of the Worst Season, 1879; and the Average of Forty Years, 1852-1891.

Description of Manures (Quantities per Acre).	Dressed Grain (per Acre). Best Season, 1863.	Worst Season, 1879.	Difference.	Average, 40 years, 1852-91.
	Bushels. *a.*	Bushels. *b.*	Bushels. *c.*	Bushels. *d.*
Unmanured	17¼	4¾	12½	13
Farmyard manure	44	16	28	34⅜
Mixed mineral manure alone ...	19⅜	5⅜	14	15
Mixed mineral manure and 200 pounds ammonium salts = 43 pounds nitrogen	39⅜	10½	29⅜	24¼
Mixed mineral manure and 400 pounds ammonium salts = 86 pounds nitrogen	53⅜	16¼	37⅛	33⅛
Mixed mineral manure and 550 pounds nitrate soda = 86 pounds nitrogen	55⅝	22	33⅝	35¼
Mixed mineral manure and 600 pounds ammonium salts = 129 pounds nitrogen	55¾	20⅝	35⅛	36½

inferences from results obtained. Thus it will be seen that all the plats suffered severely in the bad season. Compare columns *a* and *b*. In most cases (*see* columns

c and *d*) the difference between the produce of the best and the worst season approached, and in two cases actually exceeded, the average produce of the plats.

More than two thousand years ago the Romans recognized the fact that leguminous crops enriched the soil for succeeding crops—in short, discovered what is termed the "rotation of crops," a practice which is admitted to be the foundation of the improvements in our own agriculture. How, then, are the admittedly beneficial effects of alternate, as distinguished from continuous, cropping to be explained? Liebig's first definite theory on this subject assumed that the excreted matters of one description of crop were injurious to plants of the same description, but that they were not so, and might even be beneficial, to other kinds of plants. Later, he considered that, as the different plants had such diverse mineral requirements, the alternation of one kind with another relieved the soil from exhaustion, and discerned after many years that nitrogen probably played some important part in the matter. Boussingault, in chemical statistics extending over ten years, came to the conclusion that the difference in the amounts of nitrogen taken up by various crops constituted a very important element in the explanation of the benefits of rotation. Prof. Daubeny, of Oxford, in testing De Candolle's theory that the excretions of one kind of plant were injurious to plants of the same description, arrived at a negative conclusion, and recognized the validity of Boussingault's argument that the same kind of plant may continue to grow healthier on the same land for long periods of time; and experience at Rothamsted also is conclusive against the theory of injurious or poisonous excretions. Upon the whole the results at Rothamsted show that the benefits of rotation are very various. The opportunities which alternate cropping affords for cleaning the land constitute a prominent element of advantage. The difference in the amounts available within the soil of the various mineral constituents is one element in the explanation; but the facts relating to the amount and to the sources of the nitrogen of the different crops are of still greater significance. The varying requirements of the different crops, habits of growth, and capabilities of gathering and assimilating the necessary constituents have to be considered; with a variety of crops the mechanical operations of the farm, involving horse and hand labour, are better distributed over the year, and are, therefore, more economically performed.

"THE MIMIC FIRES OF OCEAN."

By G. CLARKE NUTTALL, B.SC.

NATURE dazzles the eye of man with many wonderful phenomena, but perhaps never more so than when she turns the gloomy night waters of the sea into a sheet of silvery fire. At these times every movement of the wave, every cleavage of the water by oar or prow, reveals in its dark depths a hidden fire which scintillates and sparkles with weird and mysterious light. The spectacle is one of absolute fascination, for the Spirit of Enchantment rests upon the waters and reality becomes fairyland.

The ancients, keenly alive to a sense of the supernatural, saw in this luminosity a manifestation of some unknown power, and wondered; the ignorant read in it a portent of judgment and terror; while in all ages the curious and the searchers after knowledge have speculated as to its cause. But just as nature has invested its appearance with a halo of mystery, so she has also wrapt in much obscurity its immediate cause; and thus, though in the course of centuries varying suggestions have been put forward, nothing with any finality about it has been arrived at. It was asserted truly that certain fishes were luminous; sharks have glowed and shone, shoals of herrings, pilchards, or mackerel have been moving masses of light, and the fish drawn out of the water have lain in great shining heaps, the glow of which vanished as they dried and died.

Many writers have described the passages of ships through such shoals—the sheet of moving flames—the beautiful pale greenish elf-light that the fish exhibited; while poets have apostrophized the "mimic fires of ocean" and the "lightnings of the wave," and scientists and naturalists have in turn tried to account for their power of luminosity. Some have attributed it to the presence of certain substances of a fatty nature excreted by the fish and adhering to the surface of their bodies; others have declared that it is due to a subtle power of the fish itself—a form in which the energy of life shows itself under certain conditions, just as this energy may be exhibited in heat, or motion, or electricity; others, again, have ascribed it to direct absorption and transmission of the light of the sun, and so on. Many theories have been elaborated, but none convincingly.

But now, it is asserted, the secret is laid bare.

It is wonderful how many secrets the searching light of the nineteenth century is claiming to reveal. It is, perhaps, a matter for still more wonder whether in the far future our descendants will endorse all our solutions, or whether they will not smile at some of them just as we, half contemptuously, discredit those of our ancestors. However that may be, we have, in this case, a solution offered to us that apparently approaches nearer the heart of truth than any yet put forward, in that it satisfies the various phases of the phenomenon and gives a unity and coherence to its manifestations.

It is only lately that any very serious effort has been made to study this phenomenon, but the research has been abundantly rewarded, for it is now pretty certain that the luminosity is due to the presence in the water of various kinds of bacteria.

Now, bacteria are the very smallest living organisms of which we have cognizance. Millions of them can lie on a penny; therefore, to produce the gleaming appearance recognized by us as phosphorescence, they must be present in numbers too enormous even to contemplate with our finite minds. It would be immeasurably easier to reckon with the stars for multitude than with these phosphorescent bacteria. They are colourless, rodlike bodies, only known to us in the land revealed by the highest powers of the microscope, and careful comparison shows minor differences among them. For instance, some of them are capable of independent motion—we can hardly call it swimming—others are non-motile, some are enclosed in a jelly-like covering, others are without this sheath. Their power of motion is probably due to excessively fine hairs at their extremities, which, moving to and fro in the water, act the part of oars. These cilia have not been found in all forms of bacteria which move, but their presence is inferred, since every advance in the study of motile forms increases the number of bacteria which are seen to possess them.

These light-producing bacteria are known as photo-bacteria, and so far some half-dozen varieties have been distinguished and named. The names in such cases are usually either given from the locality of their appearance (thus, photo-bacterium Balticum, found in the Baltic), from their discoverer (for example, photo-bacterium Fischeri, after Prof. Fischer), or from some striking attribute (to wit, photo-bacterium phosphorescens, the commonest light-giving species).

That they lie at the bottom of the matter—that phosphorescence is due to their presence—has been and can be proved in several rather pretty ways. It is not sufficient, of course, that we should always detect them in any examination of luminous sea-water; to prove that they are the cause of light we must be able to procure luminosity by introducing them into water that did not previously show this quality, and this can be done thus:—

Place a few of these tiny organisms into sea-water or broth prepared from fish, and keep at a suitable temperature; they can then be cultivated without much difficulty, and as they spread and develop phosphorescence appears, so that a removal of the vessel into another room shows unmistakably the glow of the familiar light. It only appears, however, at the surface of the liquid, where the oxygen of the air has free access to the bacteria; if, for experiment's sake, the supply of fresh air be cut off—that is, if no oxygen be allowed to come near them—then the little colony of bacteria loses its fascinating power and remains dull and shorn of its glory. But restore the air, and the microbes again recover their normal condition and luminosity seems a natural corollary. There is a tale told that a lady, whose husband made bacteria his study, took a leaf out of his book, and cultivated these bacteria on gelatine in such a way that as they developed they shone out the message, "Hommage à M. Pasteur." The shining letters were then photographed and the picture sent to the great bacteriologist, thus conveying in graceful form the warm appreciation in which he was held by those following in his steps.

The explanation, too, of the luminous shoals of fish is now made plain, and we can apparently get "fiery herrings" at will. No longer are we to believe that the herrings themselves, by the exercise of some marvellous power, or by the excretion of an extraordinary substance, give rise to the striking luminosity, but rather that their brightness is due to myriads of these infinitesimal bodies, which cling to their surfaces and invest them in a coat of shining light. Thus, if some herrings, newly caught, and with the sea-water still fresh on them, be placed on one plate and covered down with another, and then put into a suitable temperature and left for a day and a night, glints of light can, at the end of the time, be detected at various points on their bodies when they are examined in a dark room. If they are yet again put away for another twenty-four hours, the points of light spread until the whole of the fish are enveloped in a beautiful bluish glow. The light is then at its best, and gradually fades away as the fish putrefies and the sea-water dries up. If a little of the light-giving matter be scraped off the skins of the herrings and examined under the microscope, it shows itself to be nothing but colonies or collections of bacteria, all living at a great pace, dividing, multiplying, and developing at a tremendous rate. Each member of a colony is normally roundish in shape, but in this stage of reproduction it is continually elongating into a long ellipse, a constriction appears at the middle, and it divides into two. Each of these two in their turn elongate, become constricted, and divide. And so it goes on, the process being often so rapid that short chains are formed, the various portions being unable to break away in time. The particular bacterium which affects herrings and cod is remarkable for its great luminosity; in fact, it exceeds all other species in this quality.

It is a curious fact that the addition of a little sugar to the liquid or the gelatine on which these phosphorescent bacteria are being cultivated increases very much their power of producing light; the sugar must, however, be used with great moderation, as too much of it has a contrary effect and checks the luminosity altogether. The reason for this is that nearly all this class of bacteria require carbon as nourishment if they are to develop to their highest powers. Like much of the food we eat, it is not essential to them; they can manage very well without it, but they are all the better for having it. Now sugar is very largely composed of carbon; hence the good results which follow its presence. Glycerine, which is of similar composition, will do almost as well; from both bacteria can easily withdraw carbon. Two photo-bacteria have, however, been observed which are somewhat differently constituted; one is found round the West Indies and the other in the North Sea, and neither apparently requires sugar or glycerine in any form—in fact, either of these substances, even in the smallest quantity, appears to be directly injurious. But why this should be so it is not easy to define.

A Dutchman named Beyerinck has lately made a special study of these photo-bacteria, and has experimented with them in a great number of ways to determine, if possible, why they should thus become illuminated, and if the light plays any notable part in their life history; but his results are, seemingly, all more or less of a negative nature. He cannot find that it has any very important function. The breathing of these tiny organisms is not, apparently, in any way bound up with it; their nutrition, growth, and development go on quite well even if they are placed under such conditions that their luminosity is arrested; in no way, indeed, is it a vital process. It only seems to depend on the food which the bacteria feed upon and the presence of oxygen. Given suitable food and plenty of fresh air, and they exhibit their characteristic light; deprive them of one or the other and they no longer shine.

This knowledge helps us to understand, then, the phenomenon of phosphorescence. It is visible only at night because in the full glare of day the greater light overpowers the lesser; it is visible at certain times and seasons because the conditions are such as to evoke it. And what is favourable for the lighting up of a single bacterium is favourable for all; hence the myriad multitudes of infinitesimal units, each set glowing with its tiny light, is sufficient in the sum total to put a whole ocean aflame.

It would, of course, be presumptuous, and doubtless erroneous, to say that all the phosphorescence of the sea is due solely to photo-bacteria; it can only be asserted in the present state of our knowledge that they are certainly responsible for a great share of it. But this wonder of nature must now be regarded as yet another instance of the mighty results accomplished through the agency of the smallest of living things.

THE PETROLEUM INDUSTRY.—II.

By GEORGE T. HOLLOWAY, ASSOC. R.C.S. (LOND.), F.I.C.

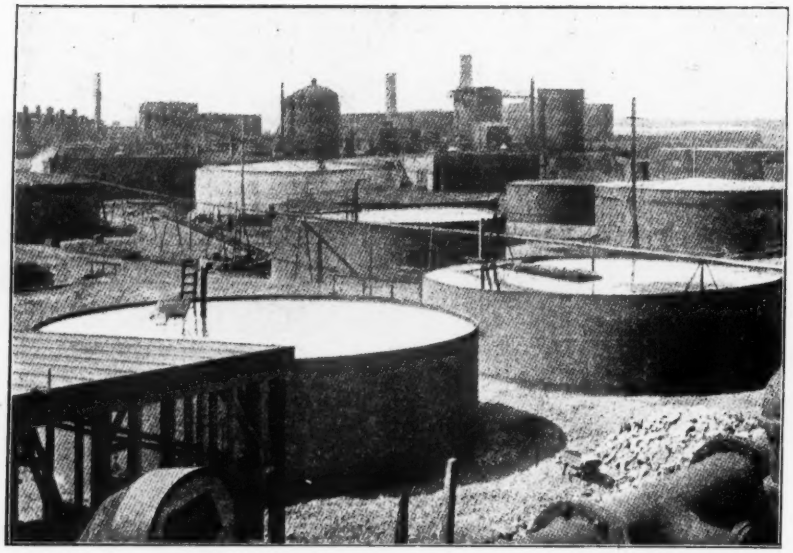
IN the earlier days of the petroleum industry the crude oil was carried from the wells to the refineries in barrels containing forty-two American gallons, at such heavy expense as to enormously increase the cost to the consumer. By land the barrels were conveyed on rough waggons over the almost roadless tracts where the oilfields were mainly located, while, where river transport was possible, barges were used as the vehicles of transportation. In 1862, however, a branch railway was carried into the oil regions of Pennsylvania, and in 1866 railway tank waggons were introduced. At first constructed of wood, and having a capacity of about two thousand gallons, these waggons were soon replaced by the boiler-iron tanks with which we are now familiar.

XUM

These tanks, of which over ten thousand are in use in the States, usually have a capacity of eight thousand American gallons.

The introduction of pipe-lines—which are now laid from all the important oilfields to the central refineries—constitutes the greatest factor among the many innovations which have, as a whole, led to the present cheap production of petroleum in the States. Each well-owner, as his oil is passed into the pipes, receives a certificate stating that he is entitled to so much oil, and these certificates are negotiable like bank-notes among those interested in the trade. Of course, all the oil passes into the common stock, so that no producer can obtain his own oil from the refinery; and for this reason any special oil, such as the heavy and valuable oils of Franklin and Smith's Ferry, is still conveyed in barrels.

The use of pipe-lines was proposed in 1860, but the first successful line was laid in 1865. Notwithstanding the opposition of the teamsters, who had formerly enjoyed the monopoly of the transport of petroleum, the laying of these lines proceeded rapidly from the first, and it is said that between twenty-five thousand and thirty thousand miles of pipe-lines now exist in the States.



Oil Refinery at Philadelphia.

The main pipes are usually from four to six inches in diameter, the small feeders which pass from them to the wells being about two inches. As the pipes are liable to become choked by dirt or solid hydrocarbons, a small brush, known as a "go devil," is occasionally passed through to clear them. This brush, which travels along with the oil as the latter is pumped through the pipes, is provided with ball-and-socket joints, to facilitate its progress round the bends; and it is also fitted with vanes, which ensure its rotation as it advances.

The pumps now invariably used for these pipe-lines are of the Worthington type, and work at a pressure which sometimes rises as high as one thousand five hundred pounds per square inch. The seven hundred and sixty mile length of six-inch pipe extending along the New York line is supplied by pumps of from six hundred to eight hundred horse-power, and conveys about thirty thousand gallons daily. There are eleven pumping stations, each containing two pumps. In one case a pair of these pumps forces the oil through a distance of one hundred and ten miles, but as a rule each pair serves about half that length.

Kerosene—the product of the distillation of crude petroleum used as lamp oil—is mainly conveyed in tank waggons or railway cars, tank barges, and tank steamers; but a small proportion is still sold in barrels, and, especially in the Eastern markets, considerable quantities are disposed of in tin "cases," each fitted with a screw cap and wire handle, and holding about five American gallons. So great is the sale of these cases that as much as forty thousand tons of tinplate is said to have been used in their manufacture in one year.

For ocean transport the oil is now usually conveyed in tank steamers and sailing vessels, in which the whole hold is formed in compartments or tanks to contain the oil. In order to prevent injury to the vessels from the rolling about of the oil in bad weather, the tanks are kept absolutely full, small auxiliary "expansion tanks" being fitted to them to receive any overflow when the oil expands from rise of temperature, or to supply oil to the main tanks when the bulk decreases. Practically the whole of the ocean traffic, both of kerosene, crude oil, and liquid fuel, is now controlled by these vessels, although lubricating oil and petroleum spirit, and other of the lighter petroleum products, are still conveyed in barrels. The credit for the introduction of this method of transport is due to Mr. Ludwig Nobel, who, in 1878, had two small tank steamers constructed for use on the Caspian. They were built at Motala, in Sweden, in sections, for conveyance to the Caspian, where they are said to be still in use.

In the earlier days the escape of gas and inflammable vapours from the oil led to many disastrous explosions, but the more efficient methods of ventilation now in vogue have minimized these dangers. The tanks are also now so arranged that they may be thoroughly cleansed by workmen and used for the conveyance of ordinary cargo on the return journey, and the most perishable goods are so transported.

As the crude petroleum consists of a large number of constituents in admixture, from dissolved gas and highly volatile "petroleum spirits" to such solids as paraffin wax and vaseline, it is resolved by distillation into the various components used in commerce. For this purpose various types of still have been devised, the Russians largely using the "continuous" still, in which the crude oil is supplied as fast as the distillate passes off; while, in the States, large non-continuous stills, which are cooled down and the residuum removed after each distillation, are principally in use. It is well known that, in distilling any such mixture as petroleum, some of the constituents are decomposed into other bodies which are mainly more volatile than the substance producing them. In what is known as the "cracking process" this decomposition is accentuated by allowing a portion of the distillate to condense on the cooler upper part of the still, and run back upon the hotter liquid at the bottom. This action is not allowed to take

place until the bulk of the lighter oils and "natural" kerosene have been distilled off, as it is the heavier and less valuable constituents of the crude petroleum which it is desired to decompose in order that the maximum of kerosene may be obtained. The distillate is agitated with sulphuric acid followed by a treatment with caustic soda lye, and it is finally washed by agitation with water, from which it is drawn off after settlement. The exact action of the chemical treatment is not known, but it appears to consist mainly in the removal of the tarry matters, the aromatic hydrocarbons, and the sulphur compounds, all of which injure the quality as well as mar the appearance of the oil.

The nature of the products obtained at different distilleries varies according to the market for which they are intended. The oil allowed to be burnt in lamps in England, for instance, must not "flash"—that is, give off inflammable vapour in a *closed* vessel—at a temperature below seventy-three degrees Fahren., while in some countries the standard is higher and in others lower. The principal products recognized in the trade are:—(1) The lightest, *i.e.*, the most volatile constituents, known as petroleum spirit or naphtha, which is sometimes again divided up into rhigolene or cymogene, gasoline, benzoline, benzine, etc. (2) Kerosene for burning in lamps. This, the most important of the products of petroleum, constitutes about seventy per cent. of the yield from the oil of the United States and about half as much from that of Russia—a feature which has had much to do with the greater success of the Americans. (3) Oil somewhat heavier than kerosene, but still capable of burning in suitably constructed lamps. (4) Lubricating oil, which, on account of its feebler action on metals and its less tendency to clog machinery, as compared with the animal and vegetable oils formerly exclusively used, has now practically displaced the latter in the markets of the world. (5) Paraffin wax. (6) Vaseline. And (7) residuum, or waste, now used on an enormous scale as liquid fuel. Anthracene and other compounds from which dye-stuffs may be obtained have also been separated from the residuum, but the cost has so far proved prohibitive.

The uses to which these various products have been put are very numerous. The earliest use of petroleum was, as already stated, for medicinal purposes—an application now mainly confined to vaseline and the softer paraffin waxes, which are largely used in preference to lard in the manufacture of pomatum, etc. It is stated that vaseline, as well as much of the heavier petroleum oil, is used instead of butter in the manufacture of pastry on a large scale, but it is doubtful whether it possesses any value whatever as a food.

The lightest of the petroleum spirits are used as local anæsthetics, those of lesser volatility being largely employed as solvents for waterproofing materials, varnishes, and as cleansing agents for the removal of grease spots; also in the processes of "dry cleaning" for fabrics. It is, of course, as a lighting agent that petroleum is most used, the distillates known as kerosene being employed for that purpose, and the bulk of the candles now in use are prepared from the paraffin wax obtained from petroleum.

The use of the heavier oils as lubricants has already been referred to, but it may be mentioned that the Russian oil holds the field as the best for this purpose, although its kerosene has not so good a name as that of America, mainly on account of the fact that the lamps (especially those in use in England) are especially designed for burning the American oil, which does not require so good an air supply for its combustion as does the Russian.

For use as fuel, the Russian residuum is preferred to that of America on account of its greater fluidity. Under the name "astatki," or "masut," it is largely employed as fuel for stationary and locomotive engines, marine boilers, furnaces, etc., a jet of the sprayed residuum blown into the furnace by a blast of air or steam from a nozzle being the usual method of applying it. On account of the ease with which this residuum may be stored, and, above all, of the almost total absence of smoke and dirt during its combustion and the little attention and stoking which is required, it is probable that in the near future its use on board ship will be greatly augmented.

Finally, the use of petroleum distillates for enriching coal gas, either by merely passing the gas through the highly volatile gasoline, or by decomposing the heavier oil into illuminating gas, which is mixed with the coal gas, must be mentioned, together with the large and increasing use for "petroleum engines," in which vaporized or gasified petroleum spirit, or even kerosene, is exploded with air as in the gas engines, which some practical men consider will ultimately be replaced by those using petroleum.

ON THE ECLIPSE THEORY OF VARIABLE STARS.

By Lieut.-Colonel E. E. MARKWICK, F.R.A.S.

THE theory that the variations in light of such stars as Algol are due to the presence of a dark or opaque companion star, which periodically passes between us and the bright star, is generally accepted as satisfactorily accounting for the observed changes in brightness. Vogel's almost classical determination of the elements of the system of Algol, uniting as it does the visual and spectroscopic observations, seems to have clinched the theory, and it has crystallized into a recognized fact in the text-book and lantern-slide worlds. It is with no idea of controverting this theory that this paper is written, but simply to examine some of the conditions which are attached to it, and study them from different points of view.

For this purpose five different systems, each of two bodies revolving round their centre of gravity, are propounded. The two bodies are denominated A and B respectively, and the following table gives the particulars of each:—

System.	Diameter of		Remarks.
	A.	B.	
I.	10	9	B, dark or opaque.
II.	10	7	
III.	10	5	
IV.	10	9	B, bright.
V.	10	9	B's albedo half that of A.

With these data, the diminution in the light of A by the central transit of B was calculated for every one-tenth of diameter of A that B advances on its course, supposing B to move from right to left. Thus in Fig. 1 the area of the lune D E F G was calculated when the advancing limb of B had arrived respectively at 1, 2, 3, etc. Fig. 1 shows the occulting satellite (System I.) arrived at point 3. In this particular case the area of the lune is 14·31, the distance G E (*a*) being 3. Taking the light of globe A to be represented by unity, the light cut off is ·182; the remaining light is ·818. Assume the "magnitude" of A when quite unobscured as 1·0; then the resulting mag-

nitude of the partly eclipsed globe is 1·22, based on the light ratio, 2·512. It is supposed that the distance of the bodies from us is so great that the telescope would only show them (even if both bright) as a single star.

In this way the five systems have been treated, and a series of points plotted as in Fig. 2. The abscissa represents a unit of time, *i.e.*, the period occupied by B

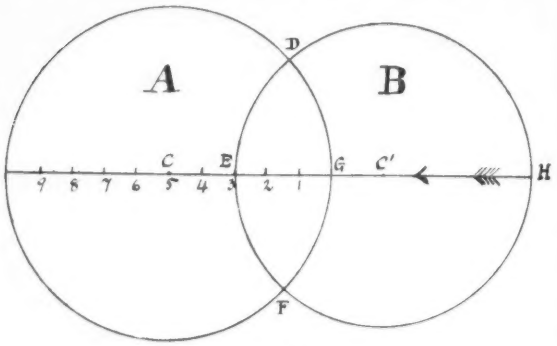


FIG. 1.

in advancing one-tenth of the diameter of A. The motion is supposed uniform and transverse to the line of sight. The ordinates are star magnitudes divided into tenths, so that the length representing one-tenth of a magnitude equals that representing a unit of time. A curve is then drawn through the points, which we may call the theoretical light curve.

It should be noted here that the shape of the light curve may be altered indefinitely by changing the ratio of time to "magnitude." But the light curves of different stars are strictly comparable provided the same ratio is maintained for all. For this reason the shape of the Algol curve, as given by Prof. Pickering in Fig. 3, differs widely from the theoretical curve in Fig. 2, simply because the above ratio adopted in the two cases is different.

In System I. the diameter of the dark globe is one-tenth less than that of the bright one. This is pretty nearly the proportion as given by Vogel for the system of Algol. Hence a very considerable diminution or drop in light of A results, owing to so much of its face being obscured by the dark globe when central.

In System II. the diameter of B is assumed seven as against ten of A. Hence the light curve is not so deep, and the central flat is longer; for, the occulting globe being smaller than in I., and supposing it to travel at same rate as before, it is, for a relatively longer time, wholly contained visually within the globe or projected superficies of A. While so contained the light of A is reduced to a minimum and theoretically does not change.

In III. the small globe is half the diameter of the large one. Here the resulting light change is so small (only 0·13 of a magnitude) that it would be practically unnoticed and undiscoverable by a method of visual observation such as Argelander's. Hence it would seem that any companion or planet smaller in diameter than ·5 of the larger could never be discovered by present methods of visual observation. If all the planets of our system could be seen projected on the sun, as seen from a star, the resulting diminution in his light would be absolutely unnoticeable.

IV. Suppose now that globe B is bright—in fact, just the same brightness, surface for surface, as A. Then we have a binary system like many known ones, except that we are supposing the distance from us so great that it is beyond the power of any telescope to "split" the pair. In this case we regard the normal light as that of globe A plus globe B. Any portion of B projected on A makes no difference, seeing that any light obscured is replaced by a similar quantity. The quantity of light, therefore, outside the central globe—that is, the lune D G F H—must be calculated and result added to that of A. This has been done for the various positions when $a = 1, 2, 3$, etc., and the fourth light curve results.

In System V. the diameter of B is still regarded as nine, against ten of A, but the albedo, or light-reflecting power, only half that of A, surface for surface. In this case the total light when the globes are separated is that of A plus that of B. When in transit, as in Fig. 1, the total light is proportional to area of A, plus half area of B, minus area of lune D E F G. This has been worked out for different positions, and the fifth light curve obtained.

All these five curves are similar in character, and the light curves of all possible varieties of binary systems can be thus represented. The amplitude of the curve will vary according as the size of the occulting body is varied. Again, the speed of the occulting body may vary, and the transit be accordingly fast or slow; also it may occupy all positions when in mid-transit, from being exactly concentric with A to just touching it externally.

With regard to the smaller globe passing behind the larger, if B is perfectly opaque and dark, the light of A is not affected. If B is luminous, and of same albedo as A, then the total light of the system will be diminished by B passing behind, exactly to the same amount as when B transits in front of A. If the albedo, as in Case V., is half that of A, then when B is partially behind A (Fig. 1) we get the total light proportionate to area of A plus half area of D G F H (the portion of B outside A). Hence with an albedo of B differing from A we get a different light curve for a transit of B in front from a transit behind A. In the latter case the light at minimum is

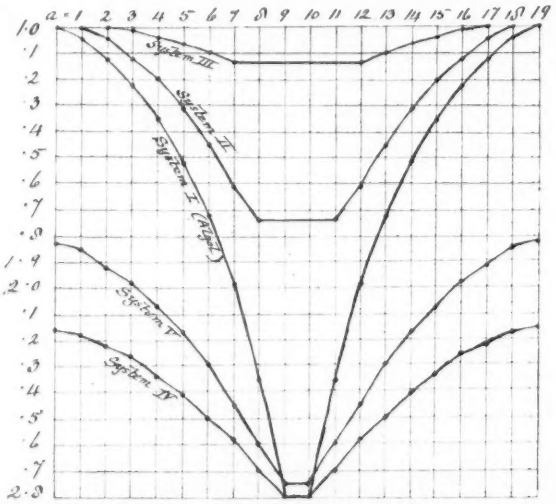


FIG. 2.—Theoretical Light Curves of Different Binary Systems.

simply that of globe A; in the former it is $A - B + \frac{1}{2}B$: that is, area of A minus half area of B. Hence the light curve for a back transit is not so deep as for a front transit.

The question now arises, Is it possible to observe and record the light changes in a star with sufficient accuracy to mark the distinguishing features of the curves as given above? All observers of variable stars know the great difficulties and sources of error attendant on visual obser-

vations. The change in position angle, change in altitude, varying transparency of the sky, and other causes conspire to prevent us determining brightness accurately to one-tenth of a magnitude, let alone anything less than this. Yet if we want to get a light curve with accuracy, we ought to have it to the one-hundredth of a magnitude.

With the photometer there seems more hope and greater promise. Fig. 3 is a reproduction of a diagram by Prof. Pickering, showing the light curves of four variable stars as resulting from photometrical observations. In the case of W Delphini it will be seen that the dots representing the observations are exceedingly close to the curve, the average deviation being between one and two hundredths of a magnitude.* However, in none of the four stars is the curve absolutely flat at minimum. I think we may conclude that for Algol type stars the shape of the light curve can only be thoroughly determined by continued observations made with some form of photometer.

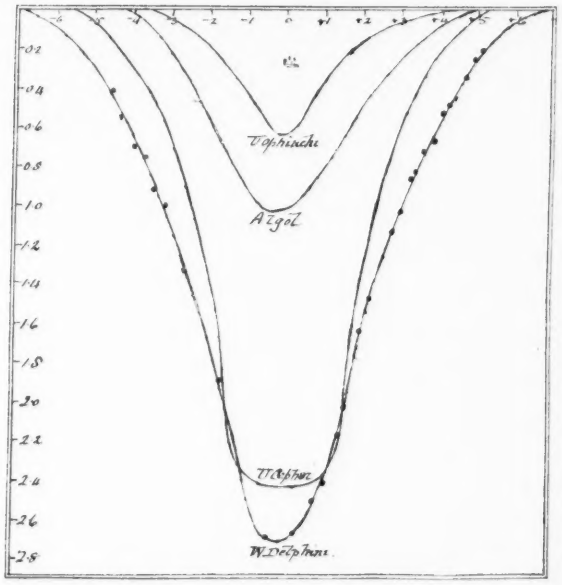


FIG. 3.—Light Curves as observed with Photometer (Pickering).

In the above notes we have supposed each star to have a sharply defined limb. In nature this may not always be the case. If we could see our sun projected on the blackness of space, the corona with its streams and wisps of light would appear to surround it, and the limb would not perhaps be so sharp as we see it through the glare of our illuminated atmosphere, which cuts off the corona. Again, some stars, for all we know, are in an earlier stage of existence than the sun, and only partially condensed from the primitive nebulous matter. So their limb or boundary would be of a cloudy, nebulous nature. In such cases our hard-and-fast light curve would be considerably modified; the change of light would be more gradual, and there would be a tendency to a rounded curve at the central depression.

Again, the bright globe might have an absorbing atmosphere, so that the light faded away towards the edges and the centre would be brighter than the limb. This might modify the typical light curve, as the eclipsing body would stop out more or less light according to the different positions occupied on the disc of the larger globe, irrespective of the actual area covered.

We have only referred to the period during which the light changes markedly; but there has been much discussion of late years as to whether Algol varies when in full light, and the matter seems at present more or less *sub judice*. When we read, however,* that under Prof. Pickering's direction, one thousand eight hundred and fifty-six photometric observations have been made of W Delphini, three thousand two hundred and ninety-six of U Cephei, two thousand five hundred and ninety-two of S Cancri, one thousand five hundred and eighty-four of S Cephei, etc., etc., we may be quite certain that the subject will sooner or later be thoroughly thrashed out, probably long before the telescope is made which will reveal to direct vision the occulting globe passing in front of its primary.

* *Astrophysical Journal*, Vol. IV., No. 5.

THE RECENT ECLIPSE.

THE LICK PHOTOGRAPHS OF THE CORONA.

By E. WALTER MAUNDER, F.R.A.S.

THE two photographs of the corona which are reproduced in the accompanying plate are copies of transparencies which were most kindly presented to us by Prof. W. W. Campbell. It will be remembered that the late Colonel C. F. Crocker, who had on two previous occasions provided the funds for eclipse expeditions organized from the Lick Observatory, had undertaken the cost of one to observe the late eclipse in India. The astronomer in charge of the expedition was Prof. W. W. Campbell, the spectroscopist of the Observatory, and he was accompanied by Mrs. Campbell and Miss Rowena Beans as volunteer assistants, travelling at their own private expense. Prof. Campbell was also assisted in India by Captain Fleet and Mr. Garwood of the Royal Navy.

Prof. Campbell's chief instrument was the great photographic telescope of five inches aperture and forty feet focal length. This was firmly fixed, and the sensitive plate was made to follow the sun. With the sun more than fifty degrees high at mid-totality, the mounting of such a monster was a very serious business; the more so as Prof. Campbell was by no means satisfied with such native carpenters as he could procure. To support the object-glass end, he built a firm wooden tower—well seen in the accompanying photograph—some twenty-three feet in height, whilst the camera end was received in a pit some eight feet deep. The plates used with this great telescope were seventeen inches long by fourteen wide, and the image of the moon was very nearly four and a half inches in diameter. The larger of the two photographs in the plate is copied from one of these, and was given an exposure of one second.

Beside this great telescope, two other photographic telescopes—the Dallmeyer and Floyd—were also employed, with focal lengths of three and five feet. With these two smaller instruments eight beautiful negatives were obtained, and the smaller photograph in the plate is an enlargement from one of these taken with the Floyd telescope with an exposure of ten seconds. The forty-foot telescope gave twelve negatives, of which nine were extremely satisfactory. The exposures varied from an "instantaneous" one up to sixteen seconds.

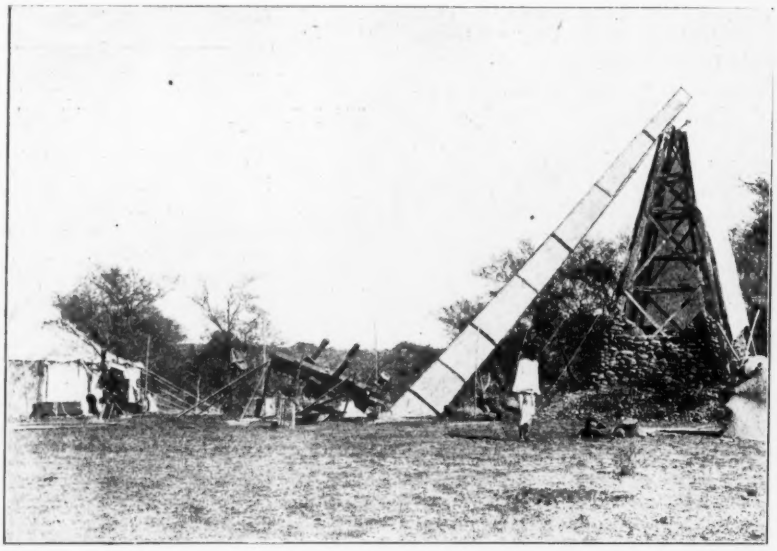
Beside the photographic cameras, Prof. Campbell had a number of spectroscopic cameras, his principal objects

* Fifty-second Annual Report of the Harvard College Observatory.

being to photograph the changes in the spectrum due to the "reversing layer," and also to secure photographs of the 1474 K line for the purpose of determining the question of the rotation of the corona. The two smaller photographic telescopes, together with the spectroscopes, were all carried on the same mounting, which was practically one of the English form, and may be seen in the centre of the photograph just beyond the base of the great telescope.

Speaking generally, the recent eclipse has been specially remarkable for two classes of photographs—those of the corona on a large scale, and those of the spectrum of the "flash." Mr. Evershed's photographs are well entitled to stand as representatives of the latter, and we may well take Prof. Campbell's beautiful picture as a representative of the former.

These large-scale photographs were undertaken at three stations: at Sahdol, where Prof. Michie Smith used a forty-foot camera like Prof. Campbell's, rigidly fixed and pointed directly to the sun; and where the Astronomer Royal used the nine-inch Thompson photographic lens of Greenwich Observatory, in combination with a Dallmeyer telephoto lens, by which the image was enlarged from a diameter of one inch to one of four. This, the most powerful photographic instrument in use in the eclipse, was fed by a cœlostat. Prof. Copeland, at Goghli, also used a lens of forty-foot focus, but mounted it horizontally and used a heliostat. There was, therefore, a wide range of method, though the resulting photographs were approximately on the same scale.



Prof. Campbell's Observing Station at Jeur, India, during the Total Eclipse of January 22nd, 1898.

In the March Number of KNOWLEDGE we pointed out that of coronæ, as seen directly, there were three well-marked types. In the May Number we drew attention to the correspondence between long-exposed photographs and the visual appearance. In the present case we wish rather to speak of those details of the lower corona which are probably common to all types, and which are very well exemplified in the present photographs.

1. *Polar Rays.*—These are seen with exceptional clearness in many of the photographs of the late eclipse. They seem to spring almost from an actual point on the sun's surface, and to diverge nearly in straight lines, but with a tendency on the part of those diverging the most widely to curve over towards the equator. Generally speaking the corona gives the idea of a flat picture, not of a body based upon a sphere and having depth as well as extension. But, on the present occasion at any rate, the polar rays seem distinctly placed at different distances, and some appear foreshortened while others are seen in their full length. It might be added here that Prof. Campbell's photograph shows better than any other with which we are acquainted a pretty little group of prominences near the north pole.

2. *Re-entering Curves.*—A prominent feature of the 1893 eclipse (at sunspot maximum) was the number of instances in which a bright group of prominences was arched over by a bright coronal line which formed a complete bridge above it. Not only so, but the coronal structure was distinctly less brilliant below this arch and round the prominence. The prominences appeared, therefore, as if they were covered by glass shades or bell jars, and it would seem as if the prominence exercised some repulsive effect upon the corona matter. In some cases arch succeeded arch, the prominence group being enclosed beneath a succession of more or less perfect re-entering curves.

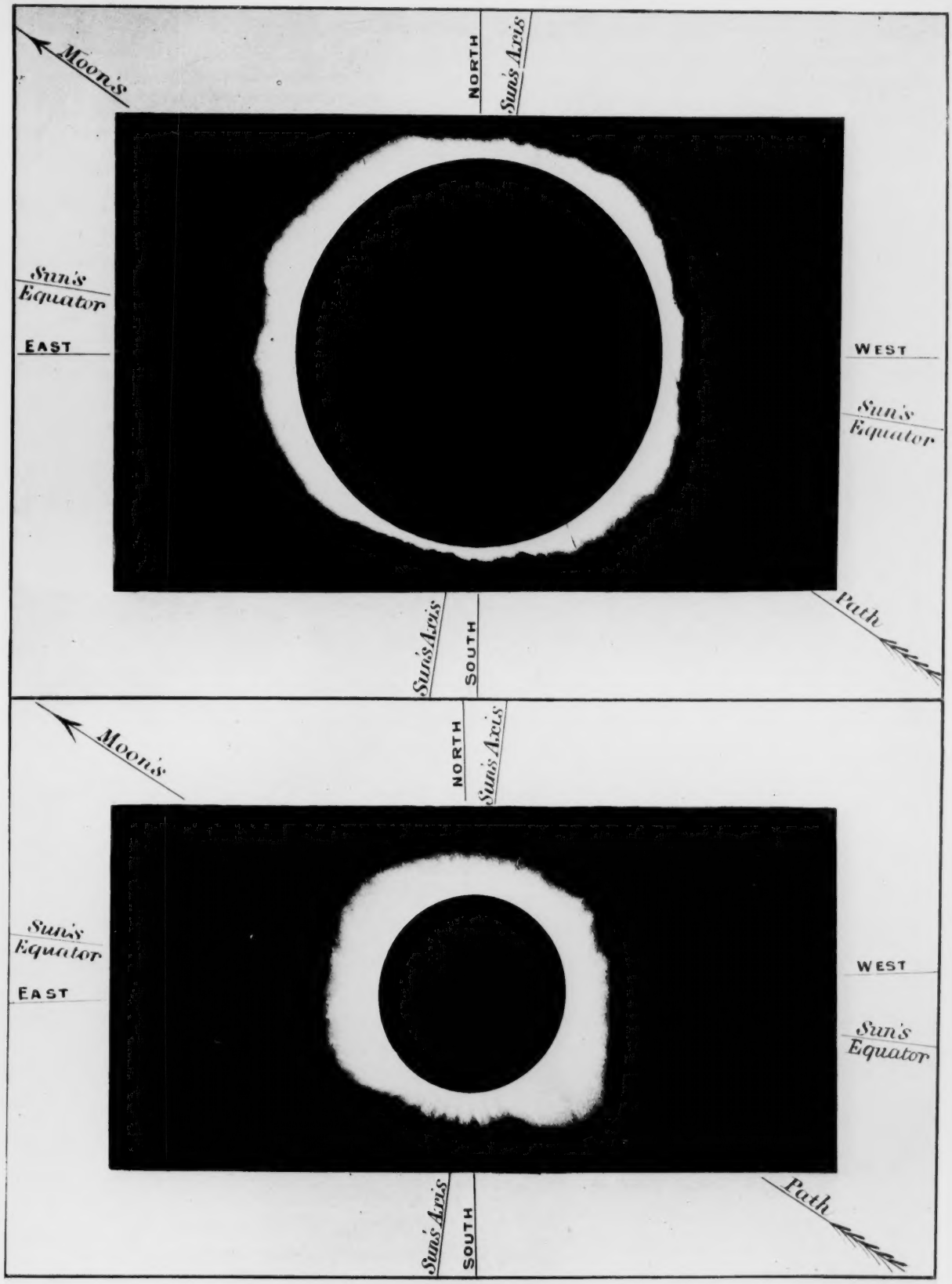
3. *Radial Lines.*—The great streamers or extensions of the outer corona are usually bordered by bright lines of a very peculiar and characteristic form, lines of double curvature which give those streamers their well-known lobed or leaflike shape. These lines often start almost tangentially to the disc. In the present eclipse there are several marked cases in which these curves, starting thus tangentially, and curving round almost concentrically with the sun, become caught by a vehement repulsive force, and are swept outward in a straight line radial to the sun. The triple ray in the north-west is, perhaps, the most striking instance of this.

Notices of Books.

Thermo-Geographical Studies. By C. L. Madsen. (Williams & Norgate.) This general exposition of the analytical method applied to researches on temperature and climate, gained for the author both an honourable mention and a silver medal in the competition for the Hodgkins prizes offered by the Smithsonian Institution, Washington, in 1893. Equations are deduced for the determination of the normal mean yearly temperature of the parallels, of the mean yearly temperature of places of given geographical latitude and longitude, and of the yearly movement in the temperature of places in the northern temperate and polar zone. A comparison is instituted between the actually observed and calculated mean yearly and monthly temperature of one hundred and twelve places situated in the middle Atlantic zones of the northern hemisphere. There is, in addition, a mass of observations and data dealing with other branches of this

XUM

XUM



THE SOLAR CORONA. 1898. JANUARY 22.

Taken at Jeur, India, by Prof. W.W. Campbell, of The Lick Observatory, Mt Hamilton, California, U.S.A.

XUM

XUM

interesting branch of natural knowledge. The volume will be a most valuable work of reference for future investigators in meteorology and physical geography, and we congratulate the author upon his worthy contribution to science.

The Flora of Perthshire. By Francis Buchanan W. White, M.D., F.L.S., F.E.S. Edited, with an Introduction and Life of the Author, by James W. H. Trail, A.M., M.D., F.R.S., Professor of Botany, Aberdeen University. (Edinburgh: W. Blackwood & Sons.) Dr. Buchanan White was an enthusiastic investigator in the realm of natural history, and most of his work as a botanist was done with a view to the publication of a "Flora of Perthshire." It is, therefore, a matter of congratulation that the materials he collected during a number of years have been brought together in the present volume. The book is a worthy memorial of an esteemed naturalist, and its value is much enhanced by the introduction and memoir from the pen of Prof. Trail, whose expert knowledge of the subject and personal regard for Dr. White have together given a wider interest to this publication than is usually possessed by a local flora.

A Student's Text-Book of Zoology. Vol. I.—Protozoa to Chætognatha. By Adam Sedgwick, M.A., F.R.S. (London: Swan, Sonnenschein, & Company, Limited. New York: The Macmillan Company.) 18s. It is now generally admitted that to successfully study zoology the student should begin by making a thorough examination of the structure of individual animals, learning the functions of their several parts as well as their relation to the external world and to one another. This constitutes what is known as the "study by types," which method owes its popularity in this country to the pioneer efforts of Huxley, who, planning courses of instruction at the old Normal School of Science, now called the Royal College of Science, adopted this plan. In this way a basis for more extended studies is secured, and it is to assist such extended studies that Mr. Sedgwick has prepared this first volume of his book, which will be completed by a second volume. But, as the author says in his preface, the book should have an additional use. It makes an admirable and handy book of reference to others interested in natural history, who will here find the general nature and habits of a large number of animals described in a readable style. When we add that the volume is provided with four hundred and seventy-two illustrations, is liberally supplied with references to original papers and other sources of information, and has all matters in dispute printed in small type, it will be seen that no efforts have been spared to make the path of the young zoologist as easy and pleasant as possible. Mr. Sedgwick tells us that he originally intended to publish a new edition of Claus's *Lehrbuch*, but subsequently departed from his intention. We think the student of the subject in this country has hereby reason to congratulate himself. The book is, beyond question, one of the best volumes on zoology at present available.

Theoretical Mechanics. By A. E. H. Love, M.A., F.R.S. (Cambridge University Press.) 12s. This recent addition to the excellent series of mathematical treatises published by the Cambridge University Press is intended for students who have some acquaintance with the elements of the differential and integral calculus and some knowledge of plane co-ordinate geometry. The book is divided into three parts: the first is preliminary in character, and is intended to accustom the student to the idea of acceleration, and to the fact that a precise description of any motion can be given by a statement of the accelerations involved; the second part is devoted to an explanation of the principles of dynamics; the last part is taken up with exemplifications of the ways in which the general theory is applied. The book is attractively printed, the subjects of the paragraphs being boldly defined by Clarendon type and the chief theorems by Italics. It is altogether an admirable treatise and will take a high place among modern works on the subject.

The First Philosophers of Greece. By Arthur Fairbanks. (London: Kegan Paul, Trench, Trübner, & Co.) 7s. 6d. Mr. Fairbanks has, in this most interesting book, prepared for the student a Greek text of the fragments of the early philosophers which represents, as accurately as possible, the results of recent scholarship; he has also added such critical notes as may be necessary to enable the scholar to see on what basis the text rests. From this text Mr. Fairbanks has prepared a translation of the fragments into English, and along with this a translation of the important passages bearing on these early thinkers in Plato and Aristotle. The reader is thus enabled to see exactly the views held by early Greek philosophers as to natural objects and phenomena, and the book will be of great value as a concise epitome of the early history of scientific opinion. It is well known that many correct ideas were held by these Greek philosophers. Thus, Thales, the founder of the school (640 B.C.—548 B.C.), taught that the moon reflects the sun's light to us, and that "eclipses of the sun take place when the moon passes across it in direct line, since the moon is earthy in character; and it seems to the eye to be laid on the disc of the sun" (p. 7). Similarly, Empedokles (494 B.C.—434 B.C.) speaks of the moon as "a borrowed light, circular in form—it revolves about the earth, as if following the track of a chariot"; and of night, "solitary, blind-eyed," as being the result of the earth "coming in front of the lights" (p. 177). Now that the idea of a gradual evolution of human thought, as well as of organic forms, is universally recognized, such a book as Mr. Fairbanks has compiled will prove of the greatest value to all intellectual readers and workers, and we are confident they will experience keen pleasure in consulting it.

SHORT NOTICES.

The Miner's Arithmetic and Mensuration. By Henry Davies. (Chapman & Hall.) 4s. net. Although the appearance of this book is at first rather forbidding, a closer inspection will reveal to the mining student who happens to look into it what a valuable treatise it is. Arithmetic and mensuration are here subordinated to the actual requirements of the practical miner—that is, examples are given which apply to mining and mine engineering, such, for example, as the calculation of the available coal in various seams. Numerous problems of this kind, with full solutions, form a conspicuous feature, and the many examinations in connection with mines and public bodies are represented by a large number of fully worked examination papers. Many of the questions, however, on the steam engine and other branches of mechanics and physics cannot be solved by the aid here given, but the examples thus brought together will be useful in classes where the several sciences required by mining students are taught; and that, presumably, is the intention of the author.

The Process Year-Book for 1898. Edited by Wm. Gamble. Price 3s. 6d. (London: Penrose & Co.) The editor is certainly to be complimented on the general excellence of this book. He has obtained a great number of beautiful illustrations and a long list of articles from eminent photographers, full of information. The whole is a splendid result of present-day skill in book illustration.

French Self-Taught. By C. A. Thimm, F.R.G.S. (Marlborough & Co.) 1s. Mr. Thimm has compressed a great number of phrases into this little book, which will minimize the student's labour in acquiring just sufficient knowledge of the language to enable one to get through a tour in France with tolerable comfort as regards making inquiries, shopping, the conversation at hotels, and so on, the useful and necessary idiomatic expressions and phrases for this purpose constituting a principal feature in the book.

XUM

BOOKS RECEIVED.

The Making of a Daisy, "Wheat out of Lilies," and other Studies in Plant Life. By E. Hughes-Gibb. (Griffin.) Illustrated. 2s. 6d.

Birds in London. By W. H. Hudson, F.Z.S. (Longmans.) Illustrated. 12s.

Essai Synthétique sur la Formation du Système Solaire. Gal. Lafouge. (Martin Frères, Chalons-sur-Marne.) Illustrated.

French Self-Taught. By C. A. Thimm. (Marlborough & Co.) 1s.

The Wonderful Century: its Successes and its Failures. By Alfred Russel Wallace. (Sonnenschein.) Portrait. 7s. 6d.

Creation Records. By George St. Clair. (David Nutt.) 10s. 6d.

Elementary Practical Zoology. By Frank E. Beddard, F.R.S. (Longmans.) Illustrated. 2s. 6d.

Krömsköp: Colour Photography. By Frederic Ives. (Photochromoscope Syndicate, Limited.) Illustrated.

English National Education. By H. Holman. (Blackie). 2s. 6d.

Elements of Descriptive Astronomy. By Herbert A. Howe. (Philip & Son.) Illustrated.

Smithsonian Report: U.S. National Museum, 1895.

A Catalogue of Earthquakes on the Pacific Coast, 1769 to 1897. By Ed. S. Holden. (Smithsonian Collections.)

Ackworth Birds. By Major W. B. Arundel. (Gurney & Jackson.)

Remarkable Eclipses. By W. T. Lynn. (Stanford.) 6d.

Weather Lore. By Richard Inwards, F.R.A.S. (Elliot Stock.) Illustrated. 7s. 6d.

A Text-Book of Entomology. By Dr. Alpheus S. Packard. (Macmillan.) Illustrated. 18s. net.

Introduction to Algebra. By G. Chrystal. (A. & C. Black.) 5s.

Types of Scenery and their Influence on Literature. By Sir Archibald Geikie. Romanes Lecture, 1898. (Macmillan & Co.) 2s.

Obituary.

By the death of Lord Playfair, which occurred on Sunday, 29th May, science—more particularly applied science—has lost one of her chief ornaments. Lyon Playfair was born in Bengal, in May, 1819, his father at that time being Inspector-General of Hospitals out there. He studied chemistry under Graham at Glasgow, and subsequently in London, in the capacity of assistant, after that distinguished chemist migrated southwards. Playfair next became a pupil of Liebig's at Geissen, in Germany, several of whose works he translated into English; and on his return to England he undertook the management of a large calico print works. About this time (1842) he travelled through England on a lecturing tour with Liebig, and was thus instrumental in arousing public attention to the advantages of combining practical science—especially chemistry—with operations in agriculture. The immediate effect of this tour was to make chemistry a popular science, and to induce colleges to open laboratories; hence it was that the Royal College of Chemistry was founded in 1845, since known as the Royal School of Mines and Normal School of Science, and, finally, as the Royal College of Science. In the early days of the history of this college, Dr. Playfair, as Professor of Chemistry, had to content himself with a laboratory fitted up in the cellar-kitchen of a house in Duke Street, Westminster. In 1851, after the Great Exhibition, he became Gentleman Usher to the Prince Consort—an appointment due to the Prince's desire to have about him a sort of scientific adviser. Probably no other man of the time was so influential in formulating the scheme which was announced from the throne at the opening of Parliament in November, 1852, when Her Majesty stated: "The advancement of the Fine Arts and of Practical Science will be readily recognized by you as worthy the attention of a great and enlightened nation. I have directed that a comprehensive scheme shall be laid before you, having in view the promotion of these objects, towards which I invite your aid and co-operation." Thus, in the following year the Department of Science and Art was born, and Playfair became one of the joint secretaries. In 1858 he was appointed Professor of Chemistry in the University of Edinburgh, the Prince of Wales and Prince Alfred being among his pupils. He published two lectures in 1870—"On Primary and Technical Education"—and had the suggestions then made been carried into effect we should not have had to wait twenty years for the adoption of the technical education scheme. His lordship was always prolific of advanced ideas relative to the practical utility of scientific education; indeed, but few men, if any, have had a more direct and practical effect on at least the physical well-being of their times. His writings have an eminently practical trend; thus—"On the Nature and Causes of Decay in Potatoes," "On the Gases evolved from Iron Furnaces," "On the Food of Man in Relation to his Useful Work," "The Disposal of the Dead," "Petroleum as the Light for the Poor"; and among the subjects he was appointed to inquire into in the interests of the public may be mentioned the herring fisheries and the cattle plague. He was one of the early Presidents of the Chemical Society; became associated with the Civil Service by what is known as the "Playfair Scheme"; he was a Privy Councillor; and served in the capacity of Postmaster-General, Chairman of Ways and Means in the House of Commons, and Vice-President of the Council. Among the numerous honours showered upon him from nearly all the learned societies of Europe, in addition to those of our own country, may be mentioned, Commander of the Legion of Honour, Commander of the Austrian Order of St. Joseph, Knight of the Portuguese Order of Conception, Knight of Wurtemberg, and Knight of the Swedish Order of the Northern Star.

Mr. Osbert Salvin, F.R.S., who died on the 1st June, will be greatly missed among ornithologists, for there were but few naturalists whose opinions were more frequently sought on controversial points in his line of study. He was born in 1835, and educated at Trinity Hall, Cambridge, where he graduated as Senior Optime in the Natural Science Tripos of 1857, after which he undertook several exploration expeditions in Algeria, Guatemala, Central America—localities which will always be associated with his name. In 1874 he accepted the Strickland Curatorship in the University of Cambridge, and filled that office till his father's death in 1883, to whose estate at Hawksfold, near Haslemere, he succeeded. Mr. Salvin will be perpetuated in literature in connection with "Biologio Centrali Americani," "Catalogue of the Strickland Collection," and his numerous papers on birds, particularly humming birds and petrels.

We regret to record the death of Mr. Herbert Sadler, F.R.A.S., who was for many years a very useful contributor to this magazine. Born on the 14th of May, 1856, he was the eldest son of the Rev. Prebendary Sadler, and he died on the 1st of June at the comparatively early age of forty-two. His education was commenced at Sherborne School and completed at Cambridge, where he distinguished himself as a linguist—particularly in Hebrew. His astronomical work was mainly connected with double stars, on which he was an authority; and, in collaboration with Mr. Latimer Clarke, he compiled a book on this subject. Mr. Sadler was elected a Fellow of the Royal Astronomical Society in November, 1876. The deceased gentleman fully appreciated the beauties of nature, and was devotedly attached to animals and flowers. As an instance of his enthusiasm for astronomy, it may be mentioned that Mr. Sadler learnt the Russian language for the sole purpose of availing himself of astronomical literature in that language.

[Mr. A. Fowler, F.R.A.S., Demonstrator of Astronomy in the Royal College of Science, has kindly undertaken to supply matter for the column, "Face of the Sky," which Mr. Sadler sustained so long and so well.]

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

THE SUN'S STELLAR MAGNITUDE.

To the Editors of KNOWLEDGE.

SIRS,—Mr. Holmes had evidently not seen Mr. Gore's article in KNOWLEDGE for June, 1895. The method adopted in that article seems to me an improvement on the earlier ones.

But now that the spectra of stars are being carefully studied, I think another method has become available. Select the binary stars with pretty certain orbits whose spectra approach most closely to that of the sun. If the surface brilliancy of these stars appears to be pretty nearly the same in all cases, we shall have a fair measure of the surface brilliancy of the sun. If, then, we can get one of these stars whose parallax as well as its orbit (in angular measure) is ascertainable, and whose stellar magnitude is known, we have the requisite data for comparison. The star best suited for this purpose is, I think, Procyon. At present the orbit is not certain, owing to the very recent discovery of the satellite whose existence had previously been only a subject of computation. But the photometric measures and determinations of parallax in the case of Procyon are remarkably concurrent, and the type of the spectrum appears to be decidedly solar. If the spectrum approaches that of the sun as closely as I believe it does (I have no spectroscope of my own), a good orbit for Procyon is probably all that we require in order to make a better estimate of the sun's stellar magnitude than has hitherto been accomplished. We have got so much into the habit of calling stars *bright* that give a large quantity of light that it seems useless to attempt to use the word in any other sense. The word *brilliant* seems less appropriated to this use, and we might therefore, perhaps, employ the word *brightness* with reference to the magnitude of the star (or quantity of its light), and the word *brilliancy* with reference to its intrinsic luminosity. Though there may be little difference in the popular use of the two terms, it is desirable to have two different words to express these qualities when we are dealing with them scientifically. But the *brilliancy* of a star, as thus explained, only represents the luminosity of the surface unit on the assumption that all stars have the same density. A diminished density will have the same effect as an increased luminosity of the surface unit, and as long as we are unable to measure the disc of the star we can hardly form a decisive opinion as to which of these causes a high or low degree of brilliancy is to be ascribed. The phenomena of Algol and some other stars of the same type, however, seem to indicate a low density in the Sirian stars, and it is, therefore, not unlikely that their high brilliancy is due rather to their great extent of surface than to the great luminosity of the surface unit. Mr. Gore's figures were based on this supposition of greater surface, or, in other words, greater diameter. In a paper which I contributed to the British Astronomical Association nearly at the same time, I proceeded on the assumption of greater brilliancy of the surface unit. Most probably both causes combine. As a star cools and condenses the surface shrinks and becomes less luminous at the same time. But figures worked out on either theory can be easily translated into the other. They represent facts which may be interpreted in different ways; but different modes of interpretation cannot change facts to fictions.

W. H. S. MONCK.

To the Editors of KNOWLEDGE.

SIRS,—In reply to Mr. Holmes, I beg to say that if he will again refer to my paper in KNOWLEDGE for March, 1898 (bottom of first column), he will find that I refer to my paper in KNOWLEDGE for June, 1895, in which I have computed the sun's stellar magnitude as -27, and this is, I think, a more probable value than $-25{\cdot}5$, which was formerly adopted.

With reference to the term "brightness," Mr. Holmes is right in thinking that I mean "quantity of light." If he will read my paper again he will find that when I refer to *brightness of surface*, I use the term "intrinsic brightness," or "brightness of surface." In the case of Sirius, I have shown that, taking its mass as 2·36 times the sun's mass (as computed by Dr. See), and assuming its density and *brightness of surface* to be the same as that of the sun, the *quantity of light* which it would emit would be only 1·773 times what the sun would emit at the same distance as Sirius; but its apparent "magnitude" shows that it is 17·88 times brighter than the sun would be at equal distances. Hence, the "quantity of light" which Sirius emits is about ten times greater than it should be, considering its mass. I think the sentence quoted by Mr. Holmes expresses this with sufficient clearness. The term "brightness" used *alone*, always, I think, means "quantity of light." Thus a first magnitude star is said to be 2·512 times brighter than a second magnitude star, etc. Mr. Holmes speaks of γ Leonis, but this star is not mentioned in my last paper, as its orbit has not been accurately determined.

J. E. GORE.

Dublin, June 10th, 1898.

Science Notes.

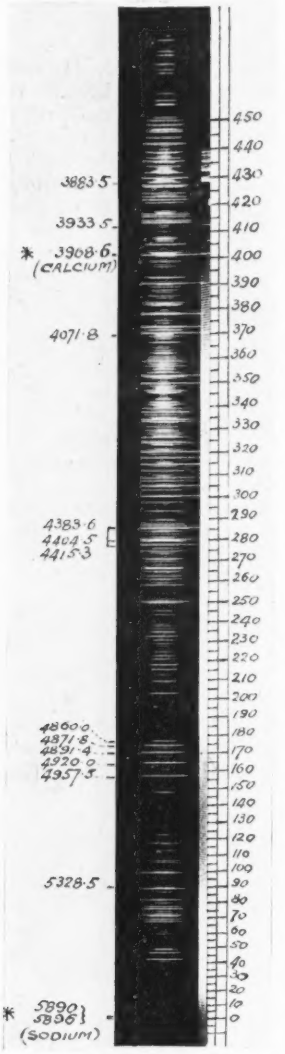
EXPERIMENTS are in progress, under the Essex Technical Instruction Committee, having for their object the destruction of charlock in barley and other crops; and it appears that a two per cent. solution of copper sulphate, applied at the rate of twenty-five to fifty gallons an acre, by means of a "knapsack strawsometer," during dry weather, and at an early period of growth, has been found completely successful in suppressing the charlock without injuring the barley.

During the past month the South-Eastern Union of Scientific Societies has held its annual congress (the third) in Croydon, the president elect being Prof. G. S. Boulger, and the retiring president the Rev. T. R. R. Stebbing, F.R.S. The place of meeting for next year is Rochester. The aim of the Union is "to win for science such benefits as are found to accrue in manufactures from division of labour; and in trade, commerce, and finance from co-operation." A perusal of the local reports of the papers read by the members in the Town Hall, where the congress was graciously received by the Mayor and Mayoress, indicates that the scope of study and research extends to every branch of natural history; and the mutual enthusiasm and goodwill which prevailed among both hosts and visitors augurs well for the future of the Union.

Experiments in wireless telegraphy are, we understand, in progress under newspaper auspices by Mr. C. Dolbear, son of Prof. Dolbear, and messages, it appears, have thus far been successfully transmitted over a distance of some fifteen hundred feet. Prof. Slaby has also devoted some attention to the subject, and is said to have sent intelligible Morse signals thirteen and a quarter miles, using two balloons filled with hydrogen to elevate the ends of the conductors to the height of one thousand feet in the air.

XUM

A very ingenious contrivance has lately been devised by Mr. Edwin Edser, A.R.C.S., and Mr. C. P. Butler, A.R.C.S., which may be utilized for the purpose of facilitating the reduction of prismatic spectra in terms of wave-lengths. Two pieces of plate-glass, each thinly silvered on one surface, are arranged with these surfaces parallel and nearly in contact. This simple combination is adjusted in front of the slit of a spectrometer, so that a ray of slightly convergent white light, when passed through, gives a spectrum consisting of white bands separated by dark intervals due to the interference of the direct ray with that twice internally reflected. If the wave-lengths corresponding to any two interference bands be known, that corresponding to any other band can be calculated or determined graphically with extreme accuracy. In order to adjust for parallelism, a spot of light, or the filament of a glow lamp, is viewed through the silvered surfaces. A long train of images, of course, is visible, and these must be brought into coincidence. If a sodium flame is now viewed through the air film, interference bands appear, which must be regulated by pressure to a maximum width, an arc lamp being employed for illuminating the collimator slit. The chief advantage of this system of calibrating spectra consists in the enormous saving of time which it will effect. A simple graphic method thus serves to determine wave-lengths—corresponding to an immense number of spectral lines—by mere inspection. When once the observer has photographed the spectrum, with the accompanying scale, all he has to do is to index the scale, and then he can commit it to the care of an ordinary attendant devoid of scientific knowledge, who may perform the reductions mechanically, in a manner somewhat comparable to the way in which a carpenter measures his boards and planks.



Comparison Scale for reduction of Spectra.

Crypton, or the "hidden stuff," is the name given by Prof. Ramsay to the recently discovered atmospheric element—a gas—the existence of which was suspected when argon was eliminated from air three years ago. The principal lines of the spectrum of crypton are green and yellow, but although heavier than argon its atomic weight has not yet been worked out. Minute in quantity, it was at first exceedingly difficult to obtain air in sufficiently large volumes as to reveal any appreciable trace of the new gas. Thanks, however, to Prof. Dewar—who can now supply gallons of air, in the liquid form, within the compass of a test-tube—in the hands of Prof. Ramsay the potency of liquid air as an instrument of research has been manifested, and one of the first chemial products obtained by its aid is, it would appear, nothing less than a new element! Its proportion in the air is about one in twenty thousand. The brilliant yellow-green is believed by Sir Wm. Huggins to be identical with the green auroral line.

"The Microbe in Agriculture" forms the subject of an article in the June Number of the *Nineteenth Century* by Dr. Aikman, in which he dwells at some length on *nitragin*,* and more particularly *alinite*—a pure culture of the *bacillus megatherium*—designed for inoculating the soil with nitrogen-fixing bacteria. He says: "When we reflect that in a phial barely a couple of inches in length, and less than a quarter of an inch in diameter, there may be contained the means of enriching an acre of ground in its most valuable of all fertilizing constituents, we realize the great advantage such a process possesses over the more costly and troublesome mode of strewing large quantities of artificial manure." It would appear that a system of co-operation obtains among these minute soil workers. While some are instrumental in initiating the first stages of decomposition, others carry on its development through successive stages, and the microbic inhabitants of the soil are classified according to the nature of the products they give rise to.

Messrs. Seeley & Co. will shortly publish a short popular account of wireless telegraphy by Mr. Richard Kerr. It explains in simple language the methods devised by Mr. Preece, Signor Marconi, Dr. Oliver Lodge, and others who have worked on this marvellous discovery. Mr. Preece will contribute a preface.

SELF-IRRIGATION IN PLANTS.

By the Rev. ALEX. S. WILSON, M.A., B.SC.

ABSORPTION of water in terrestrial plants takes place almost exclusively through the roots; very little of the rain or dew that falls on the foliage finds its way into the interior of a plant directly through the leaves or other aërial parts. The bark of the stem and branches prevents loss of water by evaporation; so does the impervious cuticle which covers the leaves; but any covering which hinders the passage of water outwards must necessarily offer a corresponding resistance to the entrance of water. For this reason those portions of their surface which plants expose to the air are, as a whole, ill adapted for imbibition. The freshening effect observed when the leaves of a parched plant are damped, arises not so much from absorption as from diminished evaporation; the water supplied by the roots to the leaves does not escape so rapidly, and the leaf-cells are in consequence kept distended.

Quite other conditions obtain in plants which grow submerged in water; the cuticle is but slightly developed, and imbibition takes place through the general surface. Aquatics accordingly quickly dry up and shrivel when

* *See* KNOWLEDGE, Vol. XX., p. 201.

exposed to the air, the thin cuticle affording little protection against loss by evaporation.

At a certain depth in most soils underground water exists; in some cases this approaches the surface, but land plants, as a rule, do not thrive where the soil is in this over-saturated condition: they depend mainly on water precipitated from the atmosphere percolating through the upper porous layers of earth in which their roots are situated.

From what has now been stated it will readily be understood that to plants growing in a region subject to occasional drought, any arrangement by which rain falling on the leaves can be quickly transferred to the neighbourhood of their roots must necessarily be highly advantageous. Many provisions of this kind exist. The rain caught by the leaves is not generally allowed to disperse at random, but is led along specially prepared courses. Were the water to lie on the leaves till it evaporated, or were it spilt irregularly, loss and miscarriage would result; but so accurate is the adjustment of plants to their environment that even this apparently insignificant loss is safeguarded by a variety of contrivances.

The first of these we shall mention is the general inclination of foliage. Many of our readers must have noticed how on a wet day in winter the rain runs down the leafless branches and descends the trunks of trees; the bark, in consequence of being kept constantly moist, assumes a green tint from the development of mosses and lichens. During summer, on the contrary, the surface of the trunks and branches of most of our trees is quite free from moisture, and the ground underneath the branches is dry. The foliage, in fact, forms a kind of thatch; the leaves slope outwards and overlap like tiles on a roof, so that the water drips from the outer extremities of the branches, producing a moist zone on the ground around the tree. Now, as the roots commonly extend in a horizontal direction as far as the branches, it is quite obvious they must benefit by this arrangement; and on extending our observations we find this principle to be of very general application.

The relative positions of the foliage leaves and absorbent roots are in most cases such as to secure to a greater or less degree the benefits of self-irrigation. The drainage of the foliage may be either centripetal or centrifugal. As examples of the latter, where the slope of the foliage

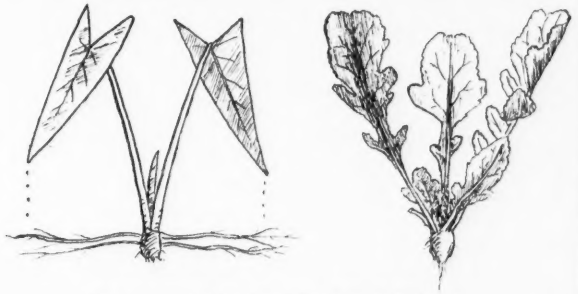


FIG. 1.—Centrifugal and Centripetal Irrigation.

is outwards, may be mentioned the lime, birch, apple, pear, plane, maple, ash, horse-chestnut, poplar, and alder. The needle-like leaves of the pine and larch are also so arranged that nearly all the rain is conducted outwards, the ground underneath the branches remaining in consequence remarkably dry. The drooping or weeping habit of many trees admits of a similar explanation.

Palms, bananas, tree-ferns; bulbous monocotyledons like the tulip and hyacinth; the turnip and beetroot, and most plants with tufted foliage, have the drainage centripetal. The radical leaves of the rhubarb, plantain, dandelion, thistle, and many others, are arranged like a rosette, and the rain flows down towards the central root-stock. In these cases the stem is either prolonged downwards into a tap-root, or the roots form a central mass of no great horizontal extent.

With centripetal drainage several secondary adaptations usually appear. Where the inclination of the foliage is outwards, as a rule the leaf-stalk is not channelled; in plants, on the other hand, which have central roots, there is usually a very conspicuous groove on the upper surface of the petiole. The common cow-parsnip is an exceedingly good example of this; its long petiole has a deep groove above. The raised edges of the groove almost close over it, and practically convert the leaf-stalk of Heracleum into a

FIG. 2.—Nodding and Auriculate Leaves.

pipe down which the rain flows towards the stem. An instructive contrast is seen on comparing an aroid, such as Callocasia or Calladium, which has widely spreading roots and leaves sloping outwards, with the rhubarb, which has a central root-stock, grooved petioles, and inward-sloping leaves.

The lamina or blade of the leaf in numerous instances exhibits a further peculiarity. The surface of the veins and midrib may be depressed, as in the primrose, below the general level of the leaf, giving rise to a series of shallow converging channels, which conduct the rain into the grooved petiole. As the raised portions of the leaf have a thin coating of wax, which renders them practically waterproof, the rain falling on these parts assumes the form of globules, and readily rolls off into the courses prepared for it. The wax-coated parts repel water; but the channels, being entirely free from wax, are easily wetted, so that rain soaks into them and speedily finds its way. Wax or bloom is seen on the leaves of the pea, woodbine, poppy, fumitory, pink, and is present more or less on all leaves. From the leaves of the cabbage water rolls off as from a duck's back, without wetting the surface. Roots are devoid of wax. On herbaceous plants with an erect stem the leaves diminish in size from below upwards; the upper ones are either sessile or but slightly stalked; they may be expanded at the base into auricles or decurrent with a fringe running down each side of the stem. The course followed by the water in its descent depends to some extent on the phyllotaxis. With the opposite arrangement the rain collected by each pair of leaves escapes between the bases of the petioles, and is led down by a groove on each side of the stem into the axils

of the leaves below. In the dead-nettle, centuary, pimpernel, and several St. John's worts, this occurs. Grooved, fluted, or ridged stems are also characteristic of such plants as the bedstraw, violet, ragwort, groundsel, knapweed, dock, wild mustard, shepherd's purse, pennycress, horsetails, umbelifers, and others; and it is interesting to observe in some of these how one cauline groove is made to serve a number of leaves. In the laboratory it is often important, when pouring a solution from one vessel into another, not to lose a drop; the chemist effects the transference easily by using a glass rod to guide the liquid. Grooved and striate stems act in the same way. The rain sometimes takes a spiral course, as in the sow-thistle. The stem of

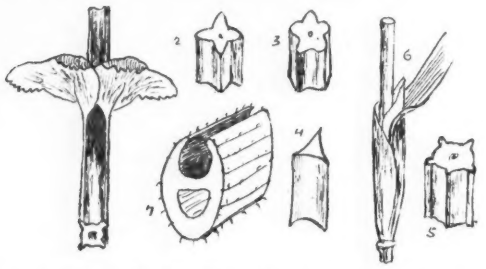


FIG. 3.—Rain-conducting Channels: 1, Dead Nettle; 2, Vetch Stem; 3, Bedstraw; 4, Carex; 5, Pennycress; 6, Ligule of Grass; 7, Leaf-stalk of Cow-parsnip.

this plant is round, smooth, and coated with wax. There are no grooves, but each leaf on the stem is sessile and has large auricles at its base, which shoot the water over on to the leaf next below. Some splashing results from the falling water—grooved stems are designed to avert this—but in the sow-thistle there is little loss, for the large leaves at the base of the plant form a capacious basin, in which most of the spray is caught. The water is projected in this instance upon the next lowest leaf, and, therefore, in its descent follows the genetic spiral; but the rain may be thrown on a leaf more remote, and then there are several spiral streams circulating round the stem.

The foxglove and mullein have nodding leaves; one portion of the rain drains inwards, but as the upper part of each leaf slopes outwards, some water flows to the apex and drops down on one of the lower leaves, where it is again deflected towards the stem. As the lowest leaves are much larger than the others, the great proportion of rain falling on the plant is ultimately collected in the vicinity of the root, and the loss through splashing is reduced to a minimum. But it must not be assumed that this is the end of all the grooves which occur on leaves and stems; many of the narrower furrows resist the entrance of water, and are probably of use in preventing rain from gaining access to the stomata. Furrows of this description are found in a number of grasses. There are also some grasses with an arrangement which prevents water lodging between the sheathing petiole and the haulm or stem; the ligule acts as a kind of dam, which forces the water that flows down from the leaf-blade to escape at the sides of the lamina and descend on the outside of the sheathing petiole. On the leaf-stalk of the Nile lily, whose white trumpet-shaped spathes are familiar objects in florists' windows, there is a similar contrivance.

The absence of wax and a peculiar smoothness of surface enables one easily to distinguish those channels which act as rain conductors. They recall irresistibly the shallow gutters of clay employed for the distribution of water, seen in Egypt and other lands where from time immemorial artificial irrigation has been practised.

Conducted by HARRY F. WITHERBY, F.Z.S., M.B.O.U.

A BRITISH-TAKEN SHEARWATER IDENTIFIED FOR FORTY-FIVE YEARS AS *Puffinus obscurus*, NOW FOUND TO BE *P. assimilis*.—In the 1889 edition of Mr. Howard Saunders's well-known "Manual" will be found, under the heading of the Dusky Shearwater (*Puffinus obscurus*), a description of a bird which was brought to Yarrell by Mr. B. Blackburn, who said that it was caught on a small sloop off Valentia Harbour, in County Kerry, on May 11th, 1853. This specimen was exhibited at a meeting of the Linnæan Society. Another specimen was found dead in Suffolk about April 10th, 1858, and was exhibited by Mr. Osbert Salvin at a meeting of the Zoological Society. At a meeting of the British Ornithologists' Club, held on March 16th, 1898, Mr. Howard Saunders exhibited the Valentia specimen, and remarked that "recent investigations by Mr. Ogilvie Grant in the islands near Madeira, as well as Mr. Boyd Alexander in the Cape Verde Archipelago, had aroused a suspicion that there might be an error in the identification of the Irish specimen. The authorities of the Science and Art Museum of Dublin, having kindly forwarded the example in question, for comparison with the specimens of *P. obscurus* in the British Museum, it is clearly established that this is not *P. obscurus*, but the closely allied *P. assimilis* of Gould. This may be distinguished from *P. obscurus* by its smaller size, by the white or pale centres to the inner webs of the primaries, the white under tail-coverts, and a more decided white line on each side of the neck. The identification is confirmed by Mr. Osbert Salvin. *P. assimilis* breeds in the islands of the Madeira and the Canary groups, as well as in the Cape Verde Islands, while *P. obscurus* breeds in the Bermudas and the Antilles. Both species have a wide range."

EARLY ARRIVAL OF THE SWALLOW (*H. rustica*).—I saw the first swallow this year on March 14th. This is to me a record date for swallows, my previous earliest date being March 25th. Perhaps the general mildness of the season may account for this. Has anyone else seen one so early?—E. SILLENCE, Church Street, Romsey.

White Wagtail in County Mayo (*The Field*, May 21st, 1898).—Mr. Robert Warren reports that Mr. Kirkwood found a party of five of these birds on Bartragh Island, County Mayo, on April 30th, and a flock of fifteen on May 10th. Mr. Kirkwood secured in all six specimens. *Motacilla alba* has now been recorded only six times for Ireland, and it is a curious fact that five of these occurrences have been on Bartragh Island, the other being on Achill Island. Further search along the west coast of Ireland, which has been much neglected by ornithologists, may result in establishing the White Wagtail as a regular spring visitor to Ireland.

All contributions to the column, either in the way of notes or photographs, should be forwarded to HARRY F. WITHERBY, *at 1, Eliot Place, Blackheath, Kent.*

NOTE.—The first issue of KNOWLEDGE containing British Ornithological Notes was that for October, 1897.

BOTANICAL STUDIES.—IV.

MNIUM.

By A. VAUGHAN JENNINGS, F.L.S., F.G.S.

IN our last study * we examined the reproductive process and life history of a *Jungermannia* as a type of the lower mosslike plants which are grouped together under the name of *Hepaticæ* or *Liverworts*. It was observed that in these forms—among the lowest of truly terrestrial plants—the *oöspheres* or egg-cells are contained in special flask-shaped structures or *archegonia*: that the fertilized egg-cell gives rise to a *sporophyte* consisting of a globular *spore case* or *capsule*, borne on a colourless stalk or *seta* which has its base embedded in the tissues of the parent shoot; that the whole contents of the capsule break up into spores and elastic filaments (*elaters*), which are liberated by the bursting of the capsule wall into four segments; and that the germination of these spores produces a more or less developed cell filament (*protonema*), from which buds a new *Jungermannia* plant to bear when mature the reproductive organs in its turn. It is now proposed to compare with this story the life cycle of one of the true mosses.

We may safely start with the statement that the life history of a moss resembles in its main features that of a Liverwort, though there are important differences in detail. In selecting a type for study one looks for a form that is at once abundant and widely distributed, easy to recognize, habitually fertile, and large enough for easy manipulation. The genus *Mnium* is less universally obtainable than *Funaria* or *Polytrichum*, but it combines a typical sporophyte borne on a leaf-bearing plant which is at once conspicuous, beautiful, and easy of study, even with a lens and knife if a microscope is not at hand. It is one of the forms with hanging bell-like capsules, and was formerly included in the wide generic type *Bryum*. The species of *Mnium* have stems from one to three inches in height, and broad, dark green, large-celled leaves. They may be found on wet banks in woods, and especially in the shady hollows among the rocks of our mountain districts. Taking any of the species, we may start our story, not with the anatomy of the plant, but with the single cell from which the plant has arisen.

M. punctatum is perhaps the commonest and best for study. It has large, wide, entire leaves, blunt at the tip; while *M. hornum* has the leaves longer, narrower, pointed, and toothed at the margin. *M. undulatum* (Neck) is the largest and most beautiful species, with long, narrow, wavy leaves, but is only rarely fertile. The specimens used for this article were collected in Switzerland in May last, and I am not sure of the exact species. Probably the first (E and F) is a small-leaved variety of *M. hornum*; the other seems nearest to *M. affine* (Schwaeg). The question of species is, however, of no importance for our present purpose.

When the moss spore falls on a suitable spot under conditions favourable for germination, its protoplasmic contents, covered by the delicate inner spore wall, protrude through an opening in the outer wall and grow out in the form of a thread, which soon becomes divided into consecutive cells by transverse walls, gives off side branches, and develops root filaments or rhizoids. This cellular thread is, as in the Liverworts, known as the *protonema*. The cells which are exposed to light develop chlorophyll granules, and the whole can thus live for a time as an independent plant. Repeated branching of the filaments and the interlacing of their ramifications with those developed from other spores frequently results in the formation of bright green patches of felted threads, such as may be commonly seen on moist clay banks. Apart from characteristic colour, texture, and appearance under the microscope, which soon become familiar by observation, the most distinctive feature of the moss protonema is the appearance on it of minute buds, which, as they increase in size, are seen to be young moss plants.

At various points on the protonemal thread little side outgrowths appear, which become divided into upper and lower cells by oblique partitions. From the lower cells new threads grow out like those of the protonema, but they remain colourless, penetrate the soil, and develop into "root" filaments or rhizoids. The upper cells, by continued elongation and repeated subdivision by longitudinal and transverse walls, grow up into aërial shoots, giving off leaves in succession behind the growing apex and constituting the moss plant. The protonema, by spreading over a relatively wide area, living and assimilating food, and then producing numerous buds at different points, is evidently of great importance in increasing the chances of survival.

It is with the reproductive processes of the plant that we are at present concerned. Almost everyone knows by sight the graceful capsules carried on slender stalks which rise from the moss tufts of walls and woodland banks, tree-trunks, and mountain rocks; and almost everyone is content to regard them as a "moss fruit," growing at the top of a continuation of the stem. It is only by a careful—though by no means difficult—study of the tips of the moss stems that we can find out the real meaning and mode of origin of the "moss fruit."

In the genus we have selected, fruiting is common and conspicuous in most of the species. The *antheridia* and *archegonia* occur on separate plants in the axils of leaves at or near the apex of the stem. In the male plants the tip of the stem is flattened out into a sort of "head" or "capitulum," reminding one of the inflorescence of a daisy or dandelion; and on this will be found numerous antheridia closely crowded together, but surrounded by barren "hairs" or *paraphyses*—structures not met with in the Liverworts. Looked at from above these give the appearance of a round brown or black spot as large as a pin's head, surrounded by a ring of spreading green leaves considerably larger than those of the stem and often differing in detail from them. In the female plants there is no such marked modification of the tip of the stem, though it is slightly enlarged in some species, and the leaves round the archegonia may be slightly larger than the ordinary leaves. It is best to select a tuft in the early fruiting stage and examine those on which young sporophytes occur, or the apparently sterile plants occurring among these.

To study these organs more carefully it will be best first to cut longitudinally through the middle of a male flower with a sharp knife, and examine with a lens. Among the bases of the terminal leaves the antheridia will be seen as elongated, straight, or slightly curved sacs. Mixed with them are the numerous club-shaped hairs known as *paraphyses*, which do not occur in the Hepatics, and the use of which is doubtful. By cutting a thin section with a razor from the surface already exposed, and examining it under a microscope, further details may be observed. The antheridia will be seen to possess a thin wall composed of one layer of cells; and their granular contents appear divided, by vertical and transverse walls, into a vast number of minute cells. If one of them is in a ripe

* KNOWLEDGE, May, 1898.

condition, the addition of a drop of water, or slight pressure of the cover-glass, will cause part of the contents to escape by an aperture formed at the apex. The *antherozoids*, or *spermatozoids*, may then be seen coiled up, each in a thin membrane, which soon bursts and sets it free.

The female plants are, as has already been noticed, less conspicuous. The top of the stem is not expanded to form a "capitulum," and the surrounding leaves are but slightly, if at all, modified. A section through the end of such a shoot will show numerous archegonia surrounded by paraphyses, which in this case have the form of long jointed hairs, without the inflated terminal cells seen in those of the male flower. The archegonia are long and slender; the "venter" or chamber containing the egg-cell is of an oval shape, narrowing below into a cellular stalk of considerable length. The elongated neck consists of the typical four rows of outer cells surrounding the channel filled with mucilage through which the spermatozoids reach the oösphere.

When fertilization has been effected there is an immediate increase in size of the oöspore, followed by division into several cells, forming the commencement of the sporophyte. The latter soon comes to consist of a cylindrical mass of cells, growing down for some distance into the tissues of the parent stem, but growing more rapidly upward. This physiological activity is not, however, confined to the sporophyte proper. The walls of the archegonium and the tissues round its base are also wakened into fresh activity, and for a time keep pace with the increase of the new generation. For a considerable time the developing sporophyte is thus surrounded by a tissue of cells representing the original wall and part of the neck of the archegonium, with others due to an increase of the tissues round its base. In time, however, the upgrowth of the sporophyte is too rapid for its surrounding wall; the latter is torn across transversely, leaving a basal portion as a sheath or "vaginula" round the base of the new plant, while the rest is carried upward as a cap or "calyptra" covering the tip.

The sporophyte grows on as a long slender rod, often till it equals in length the stem of the parent plant before there is any marked appearance of the capsule at its apex. In time the thickening of the terminal portion of the sporophyte indicates the development of the sporangium, and in this instance the successive stages are accompanied by gradual change of position; the original vertical apex becomes oblique, then horizontal, and finally pendent. During these changes the little cap or calyptra is dropped or carried away by the wind. It is only slight in this genus, but is seen at its best in the silky bells of *Polytrichum* and the long "extinguisher" of *Eucalypta*. When it has fallen the end of the capsule will be seen to be closed by a distinct circular lid, the *operculum* sharply separated by an annular ridge from the capsule wall.

The capsule changes from green to yellow and then to brown as the spores within it are ripening. In time the operculum is thrown off, and with its removal may come a burst of gold dust as the spores scatter to the winds. I say "may come" because, though the fall of the operculum probably coincides in nature with favourable conditions, yet nature has provided a second safeguard against premature dispersal of the spores. This is the *peristome*, one of the most remarkable and beautiful structures in the cryptogamic world. Originating as a series of thickenings on the walls of the cells internal to the annulus, and stretching over the end of the columella, the structure finally takes the form of a membrane divided radially into a number of wedge-shaped teeth. In some cases only one layer of cells is thus modified—one set of "teeth" produced—and the peristome is then said to be "simple." In others, such as the type we are considering, there is an inner and an outer layer, so that the peristome is double. The *outer peristome* consists of sixteen triangular teeth, marked by transverse thickening bars. In the dry state their tips meet at the centre, and close the opening of the capsule; when moist they separate and curve upward or backward. The *inner peristome* is a continuous membrane in its outer half, but toward the centre is radially divided into sixteen forked teeth opposite those of the outer circle, and sixteen pairs of jointed hairlike threads alternating with them. These inner structures are also "hygroscopic," or sensitive to changes in the moisture of the air; and their consequent expansion or contraction causes the escape or retention of the spores, according to atmospheric changes.

If a fair-sized capsule which has not yet begun to turn dry and brown is selected, it will be found possible, though not without some trouble, to cut a thin longitudinal section through the middle, and examine it under the microscope.

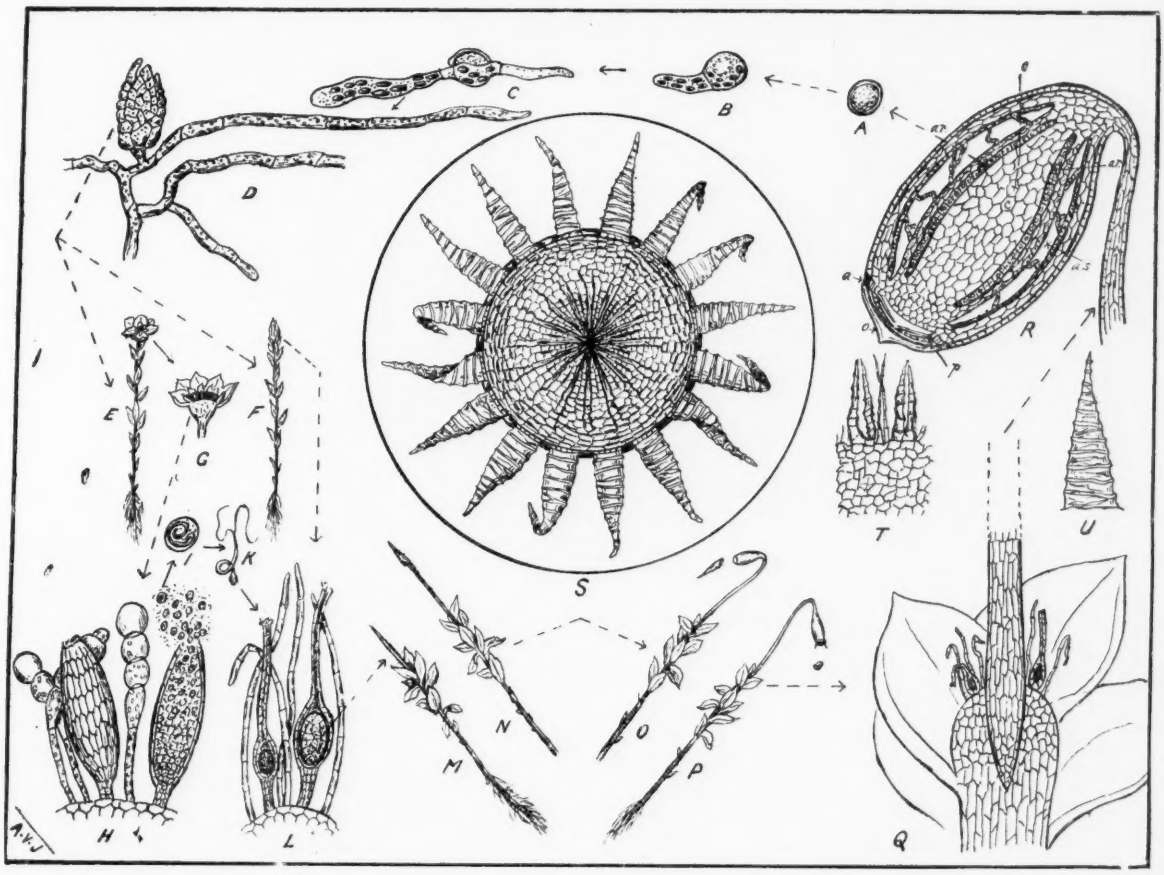
Fig. R in the illustration is a somewhat diagrammatic representation of the more important features to be observed. There is an outer *epidermal* cell-layer and two or three rows of cells internal to it, forming the *capsule wall;* a solid cylindrical tissue of cells, the *columella*, occupies the centre, and is separated from the wall by an *air space* crossed by irregular strings of cells. The outer layers of the columella, the inner layer of the wall, and the threads crossing the air space are all green, from the presence of chlorophyll granules in them. Internal to the outer green cells of the columella is a specialized layer which will vary in appearance according to the stage of development of the specimen examined. This is the *archesporium*, or layer from which the spores are developed. In an early stage it appears in section as a single row of large, square, dark, and granular-looking cells with large round nuclei. At a later stage the cells will be found in a condition of active multiplication, dividing into two and four by walls at right angles to each other. The new cells thus formed are termed the *spore mother-cells;* they subsequently become free within the capsule, lying in a semi-fluid material formed by the degeneration of surrounding cells and their cell walls. In this position they divide again, and the resulting cells assume a spherical shape, develop an outer covering of two layers (endospore and exospore), and ripen into spores. As they ripen the other contents of the capsule dry up and disappear; a drop of water on the ripe capsule causes the cells of the annulus to swell, the operculum is thrown off, the peristome teeth rise up, and separating from one another give the spores free exit to the air. Spores falling on favourable spots commence to germinate, and we thus return to the stage in the life history with which we started.

The result, then, of our study of the moss plant may be summarized somewhat as follows:—(1) The general structure and life history of a moss is similar to that of a leafy Hepatic like *Jungermannia;* but (2) there is far greater specialization in detail than in any members of the latter group, both in the oöphyte and sporophyte generations. In the sporophyte the chief differences are: (*a*) that only part of the cells of the capsule—a special layer or archesporium—develop into spores; (*b*) that no elaters are formed; (*c*) that the sporophyte grows up, protected by the calyptra, before the development of the capsule; (*d*) that the capsule wall does not split into four segments, but remains entire, the spores escaping by a terminal opening

which is closed in early stages by a lid, and subsequently by a special structure, the peristome.

From a physiological point of view the stomata and chlorophyll grains of the moss sporophyte are of no less importance. Knowing, as we do, that these structures are constantly associated with active and *independent* plant life—its respiration, nutrition, and metabolism—it is evident that the sporophyte of the moss has advanced much further than that of the Liverwort towards establishing its claim to be a separate plant. We have no evident link connecting the Liverworts and the mosses. The little mountain moss, *Andreæa*, is peculiar in possessing a capsule which bursts into four segments. Unlike the *Jungermannia*, the segments remain joined at the apex, and the general structure and habit of the plant are those of a moss. Again, in the curious minute mosses such as *Ephemerum* the protonema persists throughout the life of the plant—an apparently archaic character.

The strange *Buxbaumia*, with its rudimentary leaves and partly persistent protonema, its reproductive organs rising (as Prof. Goebel has shown) almost direct from the protonema, suggests at first sight a very primitive type of moss. Yet its capsule is large and specialized in structure, and may be a degeneration from some higher form rather than a representative of an ancestral stage. It is, in fact, impossible to say what is the lowest and simplest type of moss; and it is safer to regard the Liverworts and mosses, with their several aberrant relatives, as separate modifications descended from some type we have lost.



A.—The Spore. B.—Commencement of germination of the Spore. C.—Later stage; the Spore is throwing out a green protonemal Filament on the left, and a colourless Rhizoid on the right. D.—Protonema of *Mnium*, with a lateral Bud which will grow into a Moss Plant. (Magnified.) E. and F.—Male and female Plants of *Mnium hornum*, var. (Natural size.) G.—Section through the male "Flower." (Enlarged.) H.—Antheridia and Paraphyses of *Mnium affine*. The Antheridium on the left is empty; that on the right is discharging its contents, Spermatozoids in their Capsules, embedded in mucilaginous material. I.—Spermatozoid enclosed in Capsule. K.—Free Spermatozoid. L.—Archegonia and Paraphyses of *Mnium affine*. The Archegonium on the left is not yet fertilized; that on the right has been fertilized, and the Cöspore has begun to divide to form the young Sporophyte. M.—Plant of *Mnium affine*, var., showing young Sporophyte. N.—The same at a later stage, showing the Calyptra carried up. O.—The same, showing developed Capsule shedding the Calyptra. P.—The same at the ripe stage dropping the Operculum. Q.—Diagrammatic section through the apex of the stem and the base of the Sporophyte, showing the latter embedded in the parent tissue, and the withering Archegonia and Paraphyses round its base. R.—Diagrammatic longitudinal section of the Capsule, showing the Columella (*c*); the Archesporium (*ar*); the Air Space (*a-s*); the Annulus (*a*); the Peristome (*p*); and the Operculum (*o*). S.—The Peristome seen from above, with the sixteen outer teeth turned back. The mouth of the Capsule is still closed by the inner Peristome, consisting of an outer or basal membrane, sixteen pairs of teeth opposite the outer ones, and sixteen pairs of cilia alternating with them. T.—Teeth and cilia of the inner Peristome. U.—One of the outer Peristome teeth.

NOTES ON COMETS AND METEORS.

By W. F. DENNING, F.R.A.S.

ENCKE'S COMET.—This comet will be comparatively near the earth, but quite invisible to observers in this country. Early in July moonlight will prevent observation, and at the middle of the month the comet will have reached a southern declination of nearly fifty degrees.

Wolf's Comet.—The brightness of this object is slowly increasing. It is situated in Taurus, and moving eastwards at the rate of about forty minutes of arc per day. In the *Observatory* for May, Mr. Crommelin points out that the comet will be only twenty-seven minutes of arc distant from Mars on July 18th.

Tempel's Comet (1867, II.).—Gautier computes that the perihelion passage will occur on October 4th, but the prospect of redetecting the comet is a slender one, on account of its great distance. It has not been observed since 1879, and the comet's orbit appears to have suffered considerable disturbance in the interim, from the action of Jupiter.

Perrine's Comet (March 19th).—Rapidly increasing distance from the earth will probably soon render this object a difficult one. In regard to its position, it is, however, favourably placed for telescopic observation, as it is traversing the northern borders of Auriga, and remains visible during the whole night. Mr. Perrine, from observations at the Lick Observatory, Mount Hamilton, on March 19th, April 8th and 28th, has computed elliptical elements for this comet. He finds the period three hundred and five years, and points out that there are some suggestive orbital resemblances between the comet and those of 1684 and 1785, I. His conclusion is that these several bodies probably belong to the same family, but do not represent an identical object.

The following are ephemerides :—

COMET WOLF.

Date. 1898.	R.A. h.	m.	s.	Declination. °	′	Distance in millions of miles.
July 9	3	23	22	+20	4·6	183
,, 13	3	35	7	+19	54·9	181
,, 17	3	46	44	+19	40·9	179
,, 21	3	58	15	+19	22·7	177
,, 25	4	9	35	+19	0·2	175
,, 29	4	20	45	+18	33·4	173

COMET TEMPEL (1867, II.).

July 9	12	20	57	+ 5	43·1	206
,, 13	12	26	25	+ 4	46·4	209
,, 17	12	32	4	+ 3	48·9	212
,, 21	12	37	55	+ 2	50·9	215
,, 25	12	43	57	+ 1	52·3	218
,, 29	12	50	10	+ 0	23·6	221

COMET PERRINE (March 19th).

July 3	4	59	25	+54	49·4	250
,, 7	5	9	10	+54	31·1	253
,, 11	5	18	19	+54	12·6	256
,, 15	5	26	47	+53	54·2	259
,, 19	5	34	29	+53	35·8	262

Cometary Discovery.—It is a little remarkable that during the last eighteen months only two new comets have been discovered. Several periodical comets have been redetected, but these objects being well-assured members of the solar system their orbits and positions were known, and re-observations of this character, though important in their way, cannot be considered in the light of new discoveries. The apparent rarity in the recent visits of unknown comets is probably to be attributed, not altogether to a real scarcity of these bodies, but to the fact that they have not been thoroughly searched for by a sufficient number of observers. There is no doubt that many small comets come to perihelion and pass beyond the limits of visibility without being detected. This is evident from the fact that some of these bodies have only been first discerned long after perihelion, and when near the vanishing point, owing to their great distance from the earth. The best period for effecting cometary discoveries is in July and August, and it is to be hoped that more observers will apply themselves to this work, so that comparatively few of these interesting objects may be permitted to elude suitable record.

April Meteors.—Mr. E. R. Blakeley, at Dewsbury, observed four Lyrids on the night of April 19th, and the paths indicated a radiant at 268° + 36°, which is nearly identical with his position for the same shower on 1895, April 19th, viz., at 269° + 37° (nine meteors). These positions for April 19th, when compared with Mr. W. E. Besley's, obtained on 1898, April 21st–22nd, at 273° + 33°, strengthen the idea of a shifting radiant, in accordance with similar observations at Bristol in 1885 and 1887.

The comparison of various lists of paths by Prof. A. S. Herschel at Slough, Mr. Besley of Westminster, Mr. A. King at Leicester, and myself at Bristol, has proved that nine meteors, recorded during the April period, were observed at two stations; and I have computed their real paths as follow :—

Date. 1898.	G.M.T. h.	m.	Height at first. Miles.	Height at end. Miles.	Path. Miles.	Velocity per sec. Miles.	Radiant. °	°	Observers.
April 16	9	46	72	55	52	...	212	− 11	A. S. H. / A. K.
April 16	10	48	60	48	91	24	189	− 31	A. S. H. / A. K.
April 17	9	40	85	71	81	41	261	+ 14	A. S. H. / A. K.
April 17	9	55	57	55	24	20	236	− 13	A. S. H. / A. K.
April 17	10	28	72	70	34	23	176	− 35	A. S. H. / W. F. D.
April 17	11	12	67	44	24	23	194	+ 40	A. K. / W. F. D.
April 17	11	28	65	61	25	36	291	+ 13	A. S. H. / W. F. D.
April 18	11	55	65	58	19	32	274	+ 11	A. S. H. / W. F. D.
April 22	10	30	72	52	26	...	252	+ 49	A. S. H. / W. F. D.

The average heights were 68·3 miles at first appearance, and 57·1 at disappearance. These extremes are less than that usually found, but the difference is readily explained by the low altitudes of the majority of the radiants, and the nearly level flights of the meteors directed from them.

July Perseids.—The well-known shower of Perseids commences at about the middle of July, but the exact date has not yet been ascertained. Its radiant point on 1887, July 19th, was definitely observed at 19° + 51°, and this represents the earliest position hitherto determined. There will be little moonlight to interfere with observation this year between July 12th and 30th. The radiant moves to the east-north-east, and its position on successive nights in July, as determined from observations at Bristol during the last thirty years, is as follows :—

	°	°		°	°
July 19 ...	19	+ 51	July 26 ...	29	+ 53
,, 20 ...	20	+ 51	,, 27 ...	30	+ 54
,, 21 ...	22	+ 52	,, 28 ...	31	+ 54
,, 22 ...	23	+ 52	,, 29 ...	32	+ 54
,, 23 ...	25	+ 52	,, 30 ...	33	+ 55
,, 24 ...	26	+ 53	,, 31 ...	34	+ 55
,, 25 ...	27	+ 53			

It is to be hoped that clear weather will enable the

ensuing shower to be fully recorded during its earlier stages, and allow the radiant point to be accurately fixed on several different nights of observation. Meteors are always plentiful during the second half of July, for, in addition to the Perseids, there are meteors from Aquarius, which often become strikingly numerous towards the close of the month.

THE FACE OF THE SKY FOR JULY.

By A. FOWLER, F.R.A.S.

ALTHOUGH there now seems to be a decline in sun-spot activity, small spots may frequently be detected, and occasionally one may be seen which will repay minute examination. Even in the absence of spots, faculæ are often well worth careful observation. On the **18th** there will be an annular eclipse of the Sun, which, however, will not be visible in this country.

Mercury will be an evening star, but as it does not reach its greatest easterly elongation until August **9th**, it will not be well seen until the latter part of the month. The planet will be in conjunction with the Moon, 4° 16′ to the north, on the **20th**, at 7h. P.M., the Moon being then two days old; this circumstance may assist the observer in identifying the planet. On the **27th**, at 10h. A.M., the planet will be in conjunction with Regulus, and will be close enough to appear in the same telescopic field of view. The movement during the month is from Gemini, through Cancer, to a little east of Regulus in Leo.

Venus is an evening star throughout the month, the easterly elongation and brightness both increasing. She is now a very conspicuous object in the western sky after sunset, and in the telescope presents a phase like the Moon a few days from full, three-fourths of the disc being illuminated. She will be in conjunction with the Moon, 5° 55′ to the north, on the **22nd**, at 11h. A.M., the Moon being a little more than three and a half days old. The apparent diameter of the planet increases from 13·0″ to 15·6″ during the month. On the **10th** she sets at 9h. 57m. P.M., and on the **30th** at 9h. 15m. P.M.

Mars, during the greater part of the month, does not rise until after midnight, and will be of no interest to amateurs.

Jupiter, in Virgo, continues to be well situated for observation in the early evening. During the month his apparent polar diameter diminishes from 33·2″ to 30·8″. On the **20th** he sets at 10h. 24m. P.M.

Saturn, in spite of its low declination, is a fairly conspicuous object in Scorpio. The northern surface of the ring is visible, the apparent major axis of the outer ring on the **19th** being 41·25″, and the minor axis 17·89″. The apparent polar diameter of the planet itself diminishes from 16·8″ to 16·2″ during the month.

Uranus, with its southerly declination of about 20°, is not well placed for observation in these latitudes. It is a little east of λ Libræ. The apparent diameter of the planet is 3·8″.

Neptune, in Taurus, cannot be observed.

The Moon will be full on the **3rd** at 9h. 12m. P.M.; enters her last quarter at 4h. 43m. P.M. on the **10th**; is new at 7h. 47m. P.M. on the **18th**; and enters her first quarter at 1h. 40m. P.M. on the **26th**. She will be partially eclipsed on July **3rd**, and the phenomena will be partly visible at Greenwich. The first contact with the shadow will take place at 7h. 46m. P.M., fifty-eight minutes after contact with the penumbra, and the last contact with the shadow at 10h. 49m. P.M., finally passing clear of the penumbra at 11h. 47m. P.M. The eclipse will be almost total, its magnitude (Moon's diameter = 1) being 0·934. The Moon will rise, partially eclipsed, at Greenwich at 8h. 18m. P.M. The first contact with the shadow takes place at 49° to the east of north, and the last at 70° from north towards west.

λ Sagittarii, magnitude 3, will be occulted on July **30th**, the disappearance occurring at 7h. 31m. P.M., 98° from the vertex, and the reappearance at 8h. 41m. P.M., 283° from the vertex, reckoning eastwards.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. LOCOCK, Burwash, Sussex, and posted on or before the 10th of each month.

Solutions of June Problems.

No. 1.

(By A. C. Challenger.)

1. R to Bsq, and mates next move.

No. 2.

(By J. T. Blakemore.)

Key-move.—1. R to Kt7.

If 1. . . . K to K4, 2. B to B3ch, etc.
1. . . . K to B4, 2. R × Pch.
1. . . . B to B2, 2. B × Bch, etc.
1. . . . Kt to B2, 2. Q × Bch, etc.

CORRECT SOLUTIONS of both problems received from Alpha, W. de P. Crousaz, H. le Jeune.

Of No. 1 only from W. F. Denning, J. M'Robert, H. S. Brandreth, W. Clugston, Capt. Forde.

[Evidently a difficult pair, judging from remarks and results.]

G. G. Beazley.—1. Q × Kt is met by R to Q7.

G. A. Forde.—In No. 2, if 1. R to KR7, K to K4; 2. B to B3ch, K to B5, and there is no mate.

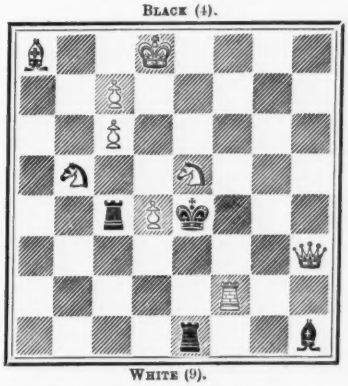
W. F. Denning.—Kt to B3 is probably answered by 1. . . . . B to B2.

PROBLEMS.

No. 1.

By A. G. Fellows.

BLACK (4).



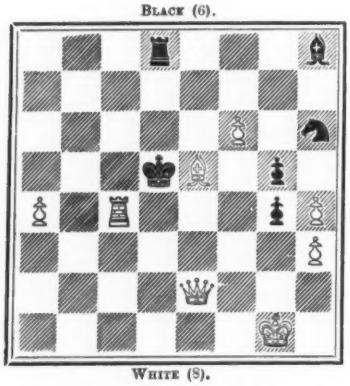
WHITE (9).

White mates in two moves.

No. 2.

By A. C. Challenger.

BLACK (6).



WHITE (8).

White mates in three moves.

CHESS INTELLIGENCE.

The Vienna tournament is now in full progress. The most remarkable feature at present is the conspicuous success of M. Alapin. At the conclusion of the tournament, a match between two old opponents, Messrs. Showalter and Max Judd, is probable. The latter was formerly a resident in the United States, but now lives at Vienna.

The Vienna Club have won one of their two correspondence games with St. Petersburg, an Evans Gambit, in which the brilliancy was on the side of the defence. The other is adjourned till after the Vienna tournament.

The Sussex championship has been won by Mr. Shoosmith, of Brighton, who did not lose a game in the contest. Mr. Reed, a former champion, was second.

Game played in the Vienna tournament :—

"Caro-Kann Defence."

WHITE. (H. N. Pillsbury.)	BLACK. (H. Caro.)
1. P to K4	1. P to QB3
2. P to Q4	2. P to Q4
3. Kt to QB3	3. P × P
4. Kt × P	4. Kt to B3
5. Kt × Ktch	5. KP × Kt
6. Kt to B3	6. B to Q3
7. B to Q3	7. B to Kt5
8. P to KR3	8. B to R4
9. P to KKt4 (*a*)	9. B to Kt3
10. Kt to R4	10. Kt to Q2
11. Kt to B5	11. B × Kt
12. B × B	12. P to KKt3
13. Q to K2ch	13. Q to K2
14. B × Ktch (*b*)	14. K × B
15. B to K3	15. QR to Ksq (*c*)
16. P to Q5 !	16. P to QB4 (*d*)
17. Q to Kt5ch	17. K to Bsq
18. Castles QR	18. Q to B2
19. R to Q3	19. R to K5
20. R to B3	20. P to QR3 (*e*)
21. Q to Q3	21. KR to Ksq
22. B × P !	22. K to Q2 (*f*)
23. B to K	23. Q to R4
24. P to R3	24. P to QKt4 (*g*)
25. R to B6	25. B to B5
26. K to Ktsq	26. B × B
27. P × B	27. R × KP (*h*)
28. Q to Q4	28. R to K8ch
29. K to R2 !	29. R × R
30. Q to R7ch	10. Resigns (*i*)

NOTES.

(*a*) A bold course, but no harm seems to come of it.

(*b*) In order to avoid the exchange of Queens, but the game should be drawn now.

(*c*) Q to K3 or K to B2 are alternatives. The move made weakens the Queen's side, a fact which Mr. Pillsbury is not slow to perceive.

(*d*) Q to K5 has some points. The move chosen gives White a passed Pawn, and something else.

(*e*) There is no apparent objection to 20. R to QKt5 ; 21. Q × R, P × Q ; 22. R × Qch, K × R.

(*f*) If 22. . . . B × B ; 23. P to Q6, Q to B3 ; 24. R × B, etc.

(*g*) A desperate attempt to get some attack : but his opponent sees a little further than expected.

(*h*) This is fatal, but having regard to the dominant position of the White Rook, there is really nothing to be done.

(*i*) Mate following in two more moves.

KNOWLEDGE, PUBLISHED MONTHLY.

Contents of No. 151 (May).

	PAGE
British Bees. — III. By Fred. Enock, F.L.S., F.E.S., etc. (*Illustrated*)	97
A Valley on São Nicolau, Cape Verde Islands. By Boyd Alexander, M.B.O.U. (*Illustrated*)	100
Deserts and their Inhabitants. By R. Lydekker, B.A., F.R.S.	101
The Karkinokosm, or World of Crustacea.—III. By the Rev. Thomas R. R. Stebbing, M.A., F.R.S., F.L.S. (*Illustrated*)	104
Nebulæ and Region round γ Cassiopeiæ. By Isaac Roberts, D.SC., F.R.S.	106
The Recent Eclipse. By E. Walter Maunder, F.R.A.S. (*Illustrated*)	107
Notices of Books	109
British Ornithological Notes	112
Science Notes	112
Letters	112
Nature's Finer Forces.—Some Notes on Old Work and New Developments. By H. Snowden Ward, F.R.P.S.	114
Botanical Studies.—III. Jungermannia. By A. Vaughan Jennings, F.L.S., F.G.S. (*Illustrated*)	115
Notes on Comets and Meteors. By W. F. Denning, F.R.A.S.	118
The Face of the Sky for May. By Herbert Sadler, F.R.A.S.	119
Chess Column. By C. D. Locock	119

PLATE.—Nebulæ near γ Cassiopeiæ.

Contents of No. 152 (June).

	PAGE
The Mourne Mountains. By Grenville A. J. Cole, M.R.I.A., F.G.S. (*Illustrated*)	121
The Petroleum Industry. By George T. Holloway, ASSOC. R.C.S. (LOND.), F.I.C. (*Illustrated*)	124
Economic Botany. By John R. Jackson, A.L.S., etc.	126
Weather Accounts. By Alex. B. McDowall, M.A. (*Illustrated*)	128
The Prismatic Camera at the Recent Eclipse. By J. Evershed, F.R.A.S.	130
Occultation of 26 Arietis observed Photographically. By Edward C. Pickering. (*Illustrated*)	133
Notices of Books	134
Letters	136
Science Notes	136
Africa and its Animals. By R. Lydekker, B.A., F.R.S.	137
The Vinegar Fly and the Vinegar Mite. By C. Ainsworth Mitchell, B.A., F.I.C. (*Illustrated*)	139
A Classic Legacy of Agriculture. By John Mills	140
Notes on Comets and Meteors. By W. F. Denning, F.R.A.S.	142
The Face of the Sky for June. By Herbert Sadler, F.R.A.S.	143
Chess Column. By C. D. Locock	143

PLATE.—Eclipse Spectra.

The yearly bound volumes of KNOWLEDGE, cloth gilt, 8s. 6d., post free.

Binding Cases, 1s. 6d. each ; post free, 1s. 9d.

Subscribers' numbers bound (including case and Index), 2s. 6d. each volume.

Index of Articles and Illustrations for 1891, 1892, 1894, 1895, 1896, and 1897 can be supplied for 3d. each.

"Knowledge" Annual Subscription, throughout the world, 8s., post free.

Communications for the Editors and Books for Review should be addressed Editors, "KNOWLEDGE," 326, High Holborn, London, W.C.